NOV 11 1935

PERIODICAL ROOM

Vol. XXXV, No. 8 *Whole No. 307*

November, 1935

SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

CONTENTS:

Marine Algae of Commerce

Seventy-Five Years of Science

Spherical Hyperbolas and Parabolas

Grade Placement in Elementary Science

Procedure in Mathematics Is Misdirected

Published by THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, INC.
Publication Office: 450 AHNAIP ST., MENASHA, WISCONSIN
Business Manager: 450 AHNAIP ST., MENASHA, WISCONSIN, AND 3319 NORTH FOURTEENTH ST., MILWAUKEE, WISCONSIN
Editorial Office: 7633 CALUMET AVENUE, CHICAGO, ILLINOIS
Published Monthly, October to June, inclusive, at Menasha, Wisconsin. Price $2.50 per year: 35 cents per copy. Entered as second class matter December 8, 1932, at Menasha, Wisconsin, under the Act of March 3, 1879.

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School Science and Mathematics

A Journal for All Science and Mathematics Teachers

Published Monthly except July, August and September
at 450 Ahnaip St., Menasha, Wis.

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GLEN W. WARNER
Editor
7633 Calumet Ave., Chicago

W. F. ROECKER
Business Manager, 450 Ahnaip St.
Menasha, Wis., or
3319 N. 14th St., Milwaukee

DEPARTMENTAL EDITORS

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5743 Dorchester Ave., Chicago

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PRICE. The subscription price is Two Dollars and Fifty Cents a year; foreign countries $3.00; current single copies 35 cents.

ALL REMITTANCES should be made payable to the order of **School Science and Mathematics and mailed to the Business Manager, 450 Ahnaip St., Menasha, Wis., or 3319 N. 14th St., Milwaukee, Wis. Remittances should be made by Post Office Money Order, Express Order, or Bank Draft.** If personal checks are sent, please add five cents for collection. Foreign remittances must be made on American Exchange.

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXV NOVEMBER, 1935 WHOLE NO. 307

COMMUNITY LEADERS

In a recent lecture before the faculty and students of Teachers College, Columbia University, Professor David Eugene Smith says:

In my youth the teacher in the "academy" was looked up to with respect as a learned man. He dressed the part, acted the part, and in general honored it. Today a teacher in an equivalent position in a high school holds, in the opinions of his fellow citizens, a much lower rank. He plays bridge better, but he is rarely appealed to in a matter of public importance.

The teacher should be *the* intellectual leader in the community. He should have the inheritance, the preparation, the habits of dress, personal appearance, thought, action, and experience needed to insure such standing. If teachers acquire and maintain professional recognition as indicated by Professor Smith, it will not be so difficult for the schools to get community support. We no longer have many schools conducted in basement living rooms by impoverished "dames" or disabled old men who are prepared for no job, but many schools are in charge of teachers who have not acquired a satisfactory sense of their own responsibility or sufficient regard for the interests and importance of the teaching profession. Whose is the blame for this condition? Before looking afar for the cause, each of us needs to take a personal inventory. But it is interesting to listen again to Professor Smith as he points out some necessary steps for a solution of these problems:

But it may also be asked whether the modern demands warrant a modern course in contemporary culture similar to those in contemporary civilization, found in certain colleges. Perhaps not if modern demands, modern culture, and modern habits are to dictate. In a certain school of

education which I have visited, a considerable number of the future teachers of our children, modern teachers whose influence will dictate the manners and the general culture of the rising generation, seem to have strange views of their ability to better the schools and the world at large. I see them sitting on the entrance steps of the college which trains them as leaders, smoking cigarets, and throwing the stubs on the stairs as they go to classes in child psychology and in the better training of pupils in the elementary grades. I hear them saying "O.K.," "Yeah," "Don't be silly," and "Sez you" to their instructors in the corridors, and I find that their language on the street not infrequently is characterized by vulgarity if not profanity; but, of course, we "modernists" have no objection to personal freedom, to "self-determination," or to letting youth cultivate the habits of youth. When the tobacco interests only a few years ago, I am told, decided to spend millions in advertisements which should portray good-looking women smoking cigarets, they knew what they were doing, and they were entirely within their legal and financial rights. The campaign was a success. To say "O.K." is entirely legal: the expression has feeble dictionary sanction; but the question is whether the future teachers of children should bring themselves up to vulgarity, to lack of good manners, and to looking upon cigaret stubs as desirable features in school decoration. I sometimes wonder what the mythical Man from Mars would think of us if he could spend twenty-four hours in any one of our schools for training model teachers, ending his day by listening to our radio programs.

These two lectures* by Professor Smith are crowded with thoughts for teachers and educators. There is more real educational meat in the forty-seven pages of print required for these two lectures than will be found in forty-seven hundred pages of required reading in some courses for training teachers.

* Smith, David Eugene, "Challenging Problems in American Schools of Education," *Bureau of Publications*, Teachers College, Columbia University, New York City.

CONSERVATION IN WISCONSIN

The recent session of the Legislature of Wisconsin passed a law making the teaching of conservation of natural resources mandatory in all public schools of the state. The law further provides for teacher training in this subject by the state university, state teachers' colleges and normal schools.

This subject is one of major importance all over the United States. Each state has its individual problem, but all are similar. Science teachers should be the leaders in the movement. Watch for our article on the Wisconsin situation next month.

For Program of Annual Meeting of the Central Association of Science and Mathematics Teachers, see page 866.

A NEGLECTED TOPIC IN CHEMISTRY TEACHING

By Charles H. Stone
Boston, Massachusetts

The advances in our knowledge of the physical sciences during the past quarter century confirm the belief, which has long been growing, that the ultimate factor in the universe is energy. Out of this, under favorable conditions, matter emerges; and into this, under other circumstances matter relapses. It has been shown that matter with its electrons, protons, neutrons, positrons, etc., is essentially electrical, and electricity is a form of energy. The combination of four hydrogen atoms to form an atom of helium results in a loss of .032 units of matter which are converted into energy. Other instances may be cited. The recent experiment of bombarding uranium with neutrons with the resultant formation of element No. 93, if true, is a case in point. It may be shown that light, which is generally considered a pure form of energy, does possess a certain mass as is shown by the diversion of a ray of light when it is passed between the poles of a powerful electromagnet. Einstein has computed that a beam of starlight passing near the sun should be diverted by some 1.74 seconds of arc from its straight course, and this diversion has been established within reasonable accuracy by recent astronomical observations. Matter seems, therefore, to be simply a concomitant of energy.

Now no change in matter, whether of position, form, temperature, or composition can be accomplished without the agency of energy, either applied or evolved. Such familiar illustrations as: the melting of ice, the rusting of iron, the heat of neutralization, the electrolysis of water, the decomposition of mercuric oxide all involve the factor of energy, whether the change is physical or chemical. The uses of heat and electricity in the school laboratory are so common and numerous as to make some discussion of them under the general title of "Energy" seem almost imperative. Yet in many of our school texts in chemistry little more is said about this topic than to define energy and perhaps devote a brief paragraph to the subject. You do not hear of Energy again except in an indirect and unsatisfactory way, for the rest of the year. In Physics, to be sure, the topic receives major attention; kinetic and potential energy are defined; and much time is spent in the study of changes from one form to another, but in Chemistry, we seem not to have appreciated to the full

the vast significance of the subject and its immediate bearing on about every phase of chemical reaction.

It is probably not desirable for the teacher to take up with the class the topic "Entropy" nor to enter into a discussion of the laws of thermodynamics, but it does seem as if more should be done to direct the attention of the student to this immensely important topic than is now being done. Wherever energy is used in a chemical experiment or demonstration, should not a little time, at least, be taken to direct attention to the form of energy used and its relation to the changes produced by it? The observant student who discovers that the generator containing zinc and sulphuric acid becomes hot is pretty likely to raise the question: "How come?" Is not that the time to make some explanation before the class about heats of formation, of different energy levels, of energy absorbed or evolved as the case may be? What will be the teacher's answer to the perfectly legitimate question that any student may ask: "Why is heat needed to decompose mercuric oxide? How does the electric current break up water? Why is it easy to decompose copper oxide and so tremendously hard to decompose aluminum oxide?" Consider the energy required to decompose copper oxide (37,700 cal.) and that needed to decompose aluminum oxide (280,000 cal.). Surely the teacher must have some other answer than to say that copper is a weak element and aluminum a strong one.

No unusual experiments are needed to make certain elementary ideas clear to the student. Following are a few experiments, common enough, which may serve to illustrate the relation of energy to chemical change. Physical changes such as: melting, evaporation, distillation, etc., may also receive appropriate accompanying explanations. In any case, however, the idea of Energy should be firmly fixed in the student's mind so that every following experiment or demonstration shall awaken that idea in his thought.

1. The oxy-hydrogen blowtorch. The tremendous heat produced by this torch through the chemical union of the two gases is a matter of common observation; it may be observed in any place where steel-frame buildings are being torn down and the torch is used for cutting the framework, and in welding operations. The heat produced when 2.016 grams of hydrogen and 16 grams of oxygen combine is 69,000 cal. If the hydrogen be first atomized, as in the more recent forms of the torch, this heat is tremendously increased. Reference to a table of heats of

formation will disclose the calories set free when acetylene is used in place of hydrogen. Energy! Who can doubt it! And the student should get the idea that the greater the heat evolved in the formation of a compound, the greater must be the heat or other form of energy required to cause decomposition of that compound. In the case of water, it is clear that if 69,000 calories are liberated in its formation, then at least 69,000 calories must be required to cause its decomposition.

2. Acid and metal. When zinc and sulphuric acid react, heat is produced. Why? The answer is found again in the heats of formation. Consider the heat of formation of sulphuric acid and the heat of formation of zinc sulphate. Should it take more or less energy to decompose zinc sulphate than it takes to decompose sulphuric acid? The heat of formation of sulphuric acid is given as 192,200 cal. while that of zinc sulphate is given as 229,-600 cal. Of course heat is given off!

3. Anhydrous substances. It is well known that copper sulphate crystals, for instance, contain water of crystallization. Gently heat in a crucible about 5 grams of clear copper sulphate crystals until all water has been driven out, and the blue color has entirely disappeared. Let the powder cool. Remember, now, that heat was absorbed in order to drive out the water. Put about one gram of the gray powder in a dry test tube and add ONE DROP of water. Feel cautiously of the bottom of the tube. The blue color will, of course return, but something tremendously more important than that will happen. How are you going to explain the result? Is it not evident that the heat absorbed when the water was removed is now given up when the water is put back? What is latent heat? How is it related to this experiment?

4. Certain solutions. Fill a U tube with a concentrated solution of potassium hydrogen sulphate. Clamp the U tube in an upright position so that it hangs in a beaker of ice water. Insert platinum electrodes in the two arms and connect to a source of *direct* current, using a lamp in the circuit if the connection is made to the school lighting system, but omitting the lamp if a series of dry cells is used. After some hours a white substance $K_2S_2O_8$ will be seen forming in the tube. Energy has caused this formation.

Prepare a saturated solution of sodium acetate at 90°C. Stopper the tube with cotton batting, making sure that the liquid is perfectly clear. Let stand till cold. Feel of the tube. Remove

the batting and drop into the tube a minute speck of sodium acetate. Note the progressive change and also the temperature rise. Now why does that tube get hot? The answer is so easy I leave it to you.

5. Light. The familiar example of the photographic plate comes first to mind. How does the sun cause the change? What energy is involved?

Mix together equal amounts of mercuric chloride and ammonium oxalate solutions (4% each). Put one half of the mixture into a tube wrapped in cloth and stand the tube in a dark closet. Stand another tube containing the rest of the mixture in direct sunlight. What happens in each case after 10 minutes? Why?

6. Explosives. The tremendous energy contained in such substances as nitroglycerine, TNT, and the like cannot of course be shown in a school laboratory But try this. Powder one gram of potassium chlorate and place it in a small iron dish. The cap to a soda water bottle will answer. Pour upon this 5 ml. of a strong solution of phosphorus in carbon disulphide. KEEP AWAY. After a time something happens. Why? What explanation can you give?

There are of course many other illustrations of the relation of energy to all sorts of chemical changes. Without multiplying experiments, enough has been cited above, perhaps, to bring home to teachers the importance of the topic and also the fact that most of us have not emphasized it enough. It does not cost much when discussing the application of heat to mercuric oxide to use the phrase "heat *energy*." When decomposing water to use the term "electric *energy*" etc. Let's hammer the idea in and clinch it on the inside.

NEON LAMPS REPLACE INCANDESCENTS IN FORCING GREENHOUSE PLANTS

Neon lamps, running on the same principle as the red-glowing American street signs, have proved far more satisfactory than the conventional incandescent lamps for use in forcing plants and flowers in the experimental greenhouses of the Agricultural College of Wageningen, The Netherlands. They are more economical, partly because they convert a far greater proportion of the electric current into light and waste less as heat, and partly also because their light is rich in the yellow and red wavelengths that are most stimulating to the action of chlorophyll in the green leaves.

Among the plants so far tested have been cucumbers, strawberries, begonias, and a number of other flowers. In some of the experiments an extra supply of carbon dioxide gas was artificially administered.

EDUCATIONAL PROCEDURE IN MATHEMATICS IS MISDIRECTED

By J. Donald Watson
College of Commerce
University of Notre Dame, South Bend, Indiana

It is common knowledge that school curricula have ever lagged behind the needs of a particular era. This is indeed true today. A recent study at the University of Notre Dame reveals an instance of this tardiness of the educational framework to become adjusted to the changed conditions.

In recent years an increasing number of university students throughout the country have been majoring in business and the closely associated social sciences. Properly, they should. The problems of today are in those fields. "A Century of Progress" is mere irony while invention and material improvement is accompanied with economic and social disorders. But high school training of students in mathematics is not directed to this end, for it is planned largely for the students who will enter engineering fields.

The students majoring in business and social sciences need a different type of mathematical preparation from that of the engineering and architectural students. They need commercial arithmetic and bookkeeping. They will be working with numbers on tons, miles, etc., in statistical tabulations and with dollars and cents numbers taken from accounting records. Fundamental operations, decimals, fractions, and percentage are the basic tools. But these students must see how such tools are used in an infinite variety of business and economic situations. The mathematical work of the Department of Commerce in Washington or of a particular business enterprise is of this type. The problems require economic and social measurements, their compilation, and their interpretation. These students must know how to perform such calculations because (1) they should be able to compile date in these fields, (2) they should be able to interpret their own or other published data on economic and social conditions, and (3) they should advance themselves above the routine level of figuring and into the stratosphere which demands judgment on larger problems. Advanced alegbra, geometry, and trigonometry are not employed here.

These facts show that the high school work in mathematics of at least a fourth of the students entering colleges and uni-

versities is misdirected. Though it is admitted that algebra as abstract arithmetic is extremely important in its fundamental phases to anyone, much of the high school algebra is directed towards engineering. Geometry and trigonometry are approaches to the surveying of land, erection of buildings, and complex problems of engineering. In the past decades the task of surveying the American continent has been completed. As the country reaches its adulthood and as the need for houses, factories, and office buildings decreases, engineering and architecture offer opportunities only to a restricted number of students.

In high school most students have three semesters of algebra and two semesters of geometry. If they are not going to college, they may possibly take commercial arithmetic and bookkeeping. Conversely, if high school students take commercial arithmetic and bookkeeping, they are barred from many colleges and universities because of the traditional insistence in college requirements for algebra and geometry.

The study at the University of Notre Dame included 267 freshmen in the College of Commerce. These students were from 35 states and the District of Columbia and from 197 different high schools widely scattered over the country. The number of semesters, on an average, that a student spent in his high school work on various types of mathematics is revealed in the following table.

Algebra	2.71
Geometry	2.27
Trigonometry	0.31
Bookkeeping	0.27
Commercial arithmetic	0.18

In December of 1934 an arithmetic test was given to 148 of those students who were going to take during the second semester their first university course in mathematics of the type used in business and the social sciences. The primary purpose of the test was to classify the students in accordance to their degree of preparedness. The test revealed that those who had had no commercial arithmetic or bookkeeping in high school had an average score of 72.2 and those who had had one or several semesters had an average score of 82.2. Thus, those who had taken this type of mathematics in high school and who had not devoted their time entirely to geometry and advanced algebra were better prepared at the beginning of their university work

for the type of mathematics they planned to use during and after their university years.

The conclusion is twofold. First, colleges and universities should broaden their entrance requirements relative to mathematics so as to recognize the need of business and social science students for a background of commercial arithmetic and bookkeeping. Second, high schools should provide suitable courses in commercial arithmetic and bookkeeping and allow students to plan their work with thought to their subsequent university work.

THE TREATMENT OF DIVISION BY ZERO

By Cecil B. Read

The Municipal University of Wichita, Kansas

Judging by the reaction of students beginning college work, many teachers do not emphasize that division by zero is an operation excluded in modern mathematics. Students readily grant that $\infty + \infty = 2\infty$; $\infty / \infty = 1$, etc. Infinity is just another number; far less mysterious to the student than to an able mathematician.

It would seem that any one could clearly understand that when we say $a/b = q$, we *define* q as the number which, multiplied by b, will produce a. When $b = 0$, the definition is meaningless, for if $a = 0$, *every* number q, multiplied by zero gives zero; if $a \neq 0$, there is *no* number q which multiplied by zero will give a.

Students often assume that division is always possible, neglecting to consider that the divisor may be zero. For example, rigorous treatment gives the value of $(x^2 - a^2)/(x - a)$ as $x + a$, *unless* $x = a$. When $x = a$, the expression is meaningless, we *assign* the value $x + a$ approached as x approaches a.

Division by zero cannot be "justified" by pretending that the division is really by an extremely small number, hence division by zero gives a quotient extremely large, ∞. Logically, this also implies that $7 - 7$ is not really zero, but some very small number, for a symbol can not have two meanings.

Perhaps the greatest difficulty comes from an improper understanding of such expressions as $\tan 90° = \infty$, often found in tables, handbooks, etc. Few students seem to realize that this is an abbreviation for the statement which describes the behavior of $\tan x$ as x approaches $90°$, and not a value for

tan 90°. The unfortunate angle 90° was born without a tangent, must live without a tangent, and die without ever acquiring one. With this clearly in mind, students have no difficulty in determining the slope of a line when a formula gives $m = 5/0$. This is an operation mathematically impossible, *the line has no slope*. The inclination is the only angle less than 180° satisfying the condition, 90°.

In solving linear equations in two unknowns by means of determinants, division by zero may be encountered. Here no question of approaching a limit is involved. The operation is impossible, there is no solution. To say that the parallel lines meet at infinity appears to solve the difficulty; but the explanation is hardly satisfactory if the solution of three equations in three unknowns is attempted.

Unless a clear conception of the limiting process is introduced, the concept of infinity should be omitted in elementary work. It is better to make the correct statement that division by zero is meaningless or impossible than to leave the erroneous impression that infinity is merely, like negative or imaginary numbers, another addition to our number system. Good texts are available, rigorous discussion is possible with elementary students, why then should the subject be treated in a slipshod manner?

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MARINE ALGAE OF COMMERCE*

By Helen Jean Brown
The Ohio State University, Columbus, Ohio

Too often among inland people the impression is created that seaweeds or Marine Algae are uninteresting and have little or no economic importance. It is generally known that the animal life of the sea is dependent upon the plant life of the sea as a source of food but it is not so well known that there are a lot of direct uses made of these plants by man and that these uses amount to several millions of dollars annually. The financial and economic value of seaweeds has been recognized for over a hundred years in Scotland, Ireland, northern France, and the oriental countries. In Japan alone the commercial uses of seaweeds exceed five million dollars annually.

The algae that grow in salt water, are commonly known as seaweeds and kelps and belong to three large groups of algae: the red or Rhodophyceae, the brown or Phaeophyceae, and the green or Chlorophyceae. The word "kelp" to an English-speaking botanist suggests in particular one of the large brown seaweeds, but in commercial treatises one often sees the word kelp used to refer also to the ash derived from burning these seaweeds. This ash contains large quantities of potassium and sodium salts, and was for many years extensively used in manufacturing soap and glass until other cheaper sources were discovered.

The seaweeds, or marine algae, are more or less abundant in all parts of the world but it is chiefly along rocky coasts of the temperate regions of both the northern and southern hemisphere that they are sufficiently large and numerous to attract attention. Any visitor to the New England seashore or to the Pacific coast is conscious of the brown and red masses of plants on the rocks, which are covered at high tides and exposed at low tides. The morphological features and life histories of these plants are interesting and varied but it is not the purpose of this paper to deal with that subject.

The inhabitants of the islands off the north coast of Scotland formerly obtained a large part of their livelihood from burning seaweeds and selling the ash. Over a century ago, according to tradition, the first toast to be drunk on festive occasions by an

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* Papers from the Dept. of Botany, The Ohio State University, No. 362.

Hebridean Islander was "a high price to kelp and cattle." In the height of the prosperity of the kelp industry Scotland derived from it an annual income of about two million dollars. When soapmakers and glassmakers found it cheaper to secure the potash and soda from other sources, the kelp industries of northern and western Europe began to decline. However the brown seaweeds are still gathered for their iodine on the coasts of Japan, Scotland, and Ireland; and kelp-burning remains an industry of considerable importance in these countries.

FERTILIZER

The use of seaweeds as a fertilizer for the soil has been in vogue for centuries among farmers living in the vicinity of the sea. In northern France there were conflicts between those who wished to gather the seaweeds for fertilizer and those who wished to burn them for ash—a matter that had to be regulated by laws. On the coast of Brittany in France and on the west coast of Ireland, it is not unusual to see farmers and gardeners carting away seaweed from the shore to be used as fertilizer for the land. In Ireland the seaweed is applied to potato plots previous to planting and a dressing of it is often applied in spring and autumn to grass lands and grain fields. In many places the loose seaweed that drift in at certain seasons is sufficient for the farmer's requirements; in other places it is cut by hand from the rocks, and in a few localities in Ireland it is actually cultivated for use as fertilizer.

In the United States the practice of using seaweeds as a fertilizer for the soil is especially well-established in Rhode Island, and the Agricultural Experiment Station of this state has issued a bulletin on the subject. In Rhode Island in 1885 the value of the seaweeds used for agricultural fertilizers was $65,000, as compared with $164,000 paid for commercial fertilizers. At Rye Beach, New Hampshire, the farmers attribute their unusual success with red clover to the fact that they cover the land with seaweed and plough it under, a practice that has obtained since the founding of the colony.

Analyses of seaweed indicate that in addition to the relatively high potassium content, the dry matter of seaweeds contains from 1–7% nitrogen. Much smaller amounts of phosphorous are present; the maximum amount is about 1% and the minimum about 0.2%. The total amount of fertilizing constituents present in fresh seaweed is comparable to the amount present in barnyard manure.

For certain root crops such as beets and potatoes the use of seaweed as fertilizer is particularly desirable, since these root crops require larger proportions of potash than most other crops. Since seaweeds are especially low in phosphorous, and relatively low in nitrogenous constituents, materials high in these substances should be mixed with it, when a complete balanced fertilizer is desired.

Nearly all of the potassium salt in seaweed is in a water-soluble form and is therefore immediately available for plant use. The nitrogen and phosphoric acid which it contains only become available when the seaweed decays. This takes place slowly in the soil. Thus it is not especially valuable as a top dressing as a source of nitrogen fertilizer. If it is mixed with barnyard manure before its application it decays more rapidly and thus the nitrogen and phosphorous become available more quickly. Seaweeds as fertilizers have one particular advantage over manure, that is their freedom from weed-seeds and spores of disease-producing fungi.

SOURCE OF IODINE AND POTASH

The European seaweed-iodine industry at the present time is located in three important centers, viz.: Scotland, Normandy, and Norway. Smaller centers of this industry are located in Sweden, Denmark, Spain and Germany. About 400,000 long tons of green seaweed are collected annually in Great Britain, France and Norway. These 400,000 tons of algae yield about 175 tons of iodine, 10,000 tons of potassium salts, 3000 tons of crude salts and 7000 tons of crude washing soda. In 1911, Europe extracted 385,000 lbs. of iodine from seaweed whereas the Chilean nitrate industry marketed about 1,100,000 lbs. of iodine obtained from Chile saltpeter. In that year Japan extracted 117,493 lbs. of iodine and 136,300 lbs. of potassium iodide from seaweeds. In recent years the Japanese iodine industry has grown very rapidly but the European potash and iodine industry, which was stimulated during the World War, has since declined.

The harvesting of the seaweed for burning to derive iodine and potash is very simple. The kelp burner either cuts at ebb tide the rockweeds growing along the seashore or collects the drift weed that is washed ashore by the waves. The seaweed that is reaped along the shore is called cutweed and consists chiefly of two species of the rockweed, *Fucus* (*F. serratus* and *F.*

nodosus). The driftweed, often called deep sea tangle, that is washed upon the shore, is collected and spread out to dry. Since this driftweed consists of any seaweeds washed in by a storm, it includes several different species of algae; it contains much more potash and iodine than the rockweed and is therefore valued more highly.

The seaweeds are dried in much the same manner as hay is dried. They dry rapidly in hot, dry, summer weather and may be burned within 48 hours after cutting. Because of the difficulty in drying the weed in winter, none is gathered during this season, although more driftweed is found on the beaches at that time of year.

In Japan, the seaweed-iodine industry did not originate until the latter part of the 19th Century, but it has flourished and Japan now produces more iodine from seaweed than any other country. Recently the extraction of iodine and potash has become the most important of the seaweed industries. In 1916, the production of iodine, potassium iodide and potassium chloride from seaweeds in Japan exceeded $3,000,000 in value. The chief genera used in Japan for burning are *Laminaria*, which the Japanese call Kombu, *Ecklonia*, and *Sargassum*.

On our own Pacific Coast, species of *Macrocystis*, *Nereocystis*, *Pelagophycus*, and *Alaria* possess an unusually high content of potassium. During 1917, a time when there was such a stringent shortage of potassium salts in the United States, 7,144,000 pounds of potash were produced from kelp, which represented but a small amount of the total harvestable kelp on the Pacific Coast. Congress authorized the erection of an Experimental Kelp Potash Plant by the Bureau of Soils at Summerland, California. This plant was put into operation in August 1917 and operated continuously until the spring of 1921. During this period a complete process was developed and installed for rendering from the raw kelp a series of refined products including kelpchar, a highly active decolorizing carbon, potash salts, iodine, ammonia, kelp oils, and creosote. With the completion of this demonstration of the destructive distillation of kelp, the plant was sold to a private corporation.

During the World War the shortage of calcium acetate and its solvent derivatives was acute. There was a tremendous increase in the demand for acetone, acetic acid, and acetic anhydride. Large quantities of acetone were used as a solvent in the manufacture of smokeless powders and in preparing dopes for

airplanes. After conducting extensive investigations on the manufacture of calcium acetate and other products from kelp, the Hercules Powder Co. erected a large plant for the production of calcium acetate, potassium salts, iodine, etc. by the fermentation process of kelp. This plant was located on the bay in the town of Potash, near San Diego. Its cost was in the neighborhood of $2,000,000, which alone utilized about 24,000 tons of kelp daily. During the war over half of the kelp harvested on the Pacific Coast was fermented in this plant, but immediately at the end of the war it suspended operations. Results obtained by such companies indicated that it was not possible to produce potash alone from kelp in successful competition with foreign markets. Dr. J. W. Turrentine, who had much to do with the development of this project, maintains that it is possible to produce potash from kelp profitably by the distillation process even with potassium salts at the normal price level provided that all the by-products are utilized.

EATEN AS FOOD

In many countries, especially in the Orient, algae are consumed in large quantities. Over 70 varieties of seaweed are used for food by native Hawaiians; indeed fish and algae are the chief foods eaten by the poorer classes of natives at certain seasons of the year. They also cultivate some of the more highly prized seaweeds. The Chinese and Swiss ate certain algae to prevent goiter, long before they understood the cause of this disease. *Laminaria potatorum* is said to be an important article of diet of the natives of Australia, New South Wales, and New Zealand. A brown alga, *Durvillae utilis* is eaten in considerable quantities by the natives of Chile.

In Japan, seaweeds are of such commercial importance as vegetable foods that the natural supply is insufficient to satisfy the demand; therefore much attention has been given to their cultivation. The Japanese market over $2,000,000 worth of seaweed annually, thus it is one of the most valuable of the aquatic industries of the Japanese Empire. Much of this is exported to China, Hawaii and United States, where it is used chiefly by the Chinese. The Japanese prepare certain foods called kombu from various seaweeds. The green-dyed and shredded kombu is cooked with meats and soups and also served as a vegetable.

Very little seaweed is eaten in America; because of this, few Americans consider algae as important articles of diet. Two red

algae, Irish moss (*Chondrus crispus*) and agar-agar (chiefly *Gelidium corneum*) are the chief seaweeds eaten in the United States. The center of the Irish moss industry is at Scituate, Massachusetts. The "moss" is collected, dried, and shipped away in barrels for making "sea-moss farina," puddings, blanc mange, or jellies. This Irish moss is also used by the brewers in this country for clarifying beers, and the sizing of cloth. Dulse, a red seaweed, may often be found in a rough-dried state in the water-front markets of New York, Boston, and other seaboard cities. Those who like it commonly eat it raw and dry, as a sort of salad or relish. Mr. H. M. Colvin and Dr. T. C. Frye prepared an article of food which they called "seatron" from the kelp, *Nereocystis*, by leaching out the salts and preserving in a syrup.

AGAR-AGAR INDUSTRY

Agar or agar-agar is the commercial name applied to the dried, partially bleached, gelatinous extract of certain species of red algae. Agar has been known in the Orient for several centuries under various names. At first the algae were simply dried in the sun; later a jelly was prepared by the boiling of the seaweed. It is possible that the present manner of preparation was discovered accidentally by the freezing and thawing of a sample of jelly. Most of the agar of commerce comes from Japan, China, Malaya and Ceylon although recently an industry has been started in California.

Agar-agar has long been used for food in the Orient and is eaten in the form of jellies and as a thickener for soups, sauces and gravies. It is used in Europe and United States in food preparations such as ice cream, jellies, candies and pastries, but its chief use is for the preparation of bacteriological media for scientific use.

ALGIN

Algin, or alginic acid, is an organic acid which occurs in large quantities in many seaweeds. This colloidal substance, resembling albumen, was discovered by Stanford in 1883 and called algin. At once Stanford recognized the commercial possibilities of this substance and its derivatives and carried out extensive investigations to determine the properties and possible uses of alginic acids and alginates. The kelp plant of the Hercules Powder Co. utilized the portion of the kelp which remained after the fermentation process for the manufacture of sodium

alginate. This is the most useful of the alginates and is a valuable sizing material. It possesses many advantages over starch because it fills the cloth better, is tougher and more elastic. Moreover it is transparent when dry. It imparts to the goods a thick, clothy, elastic feeling without the stiffness imparted by starch.

Sodium alginate solutions dissolve shellac. When the resulting lacquer is dried a tough, tenacious film is formed, which is insoluble in water. Treatment with dilute acids renders this filler insoluble, but its other properties, desirable in a varnish, remain unimpaired.

MISCELLANEOUS USES

Marine algae have been used by man since prehistoric times. The American Indians made use of the giant kelps of the Pacific coast in fishing; as bait, and for making fish lines from the long rope-like stipes of the kelp, *Nereocystis lutkeana*. These stipes were washed in running water for several days, then partially dried, smoked and knitted together. After stretching they were further dried in the sun. Such lines were brittle when dry but when wet they were very strong and flexible. The long hollow stems of kelp are coiled and used as a worm condenser for distilling "hoochena" by the Eskimos in the preparation of a popular modern Arctic drink.

The most important uses of marine plants are as listed: source of iodine, potash, fertilizers, food, agar-agar, and the manufacture of alginates which have many and varied uses. As the data indicate, Japan realizes more financially from the sea plants than any other country. Whenever the United States wishes to develop the possibilities of our giant kelp beds of the Pacific Coast, we will have an added source of national wealth, as was shown during the War.

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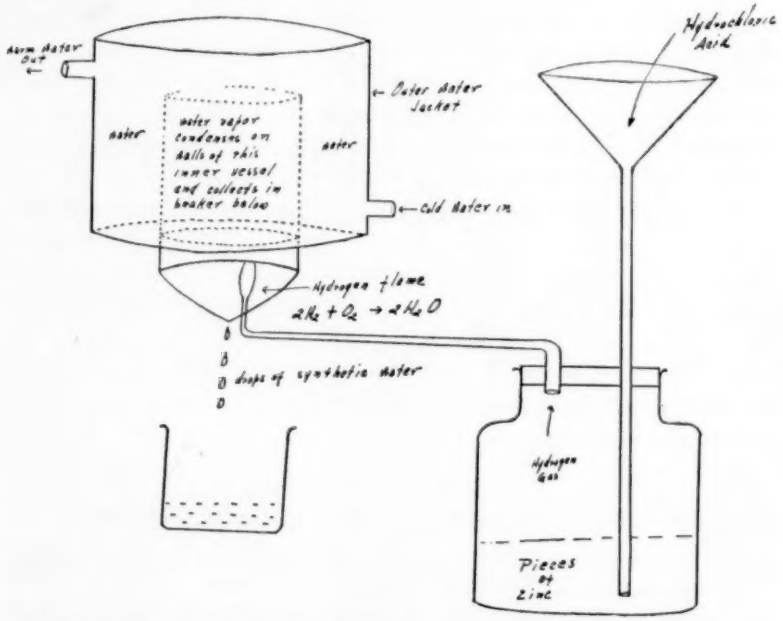
TEACHING THE SYNTHESIS OF WATER

BY HOWARD H. HILLEMANN
Custer County High School, Miles City, Montana

A difficulty in teaching one of the elementary ideas in science has been overcome by the author in the construction of a simple device which is very effective by way of practical demonstration. This device is essentially a modification of the ordinary water condenser, whereby, in illustrating how water can be synthesized from free hydrogen and oxygen, the water vapors which are produced, may be condensed and collected in very appreciable quantities.



The ordinary electrolysis experiment shows the composition of water from the analytical standpoint, but from the angle of synthesis, no equipment of any sort appears to be on the market. Ordinarily a teacher, when burning hydrogen, will insert a cold rod in the hot flame or hold a cold beaker over it,

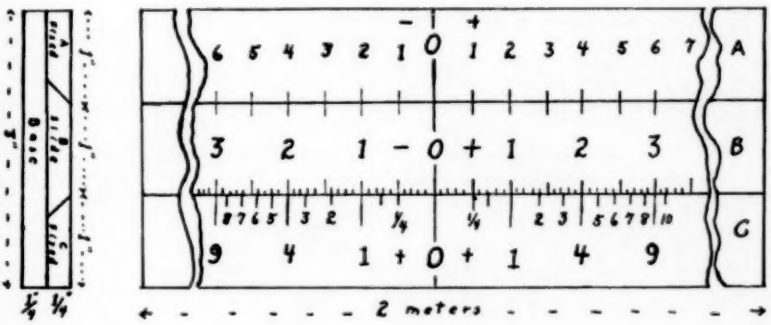
and thereby collect a film of moisture, but the high temperature of the flame usually causes sufficient heating to again evaporate the moisture. Furthermore, the amount of moisture obtained is too small to be a good demonstration of possible results.

By means of this modified condenser (see diagram above), any amount of water can be made and collected cold, and serves very well as a demonstration in chemistry and general science. Such a device can readily be made by any tinner or handyman.

A SLIDE RULE FOR QUADRATIC EQUATIONS

By I. C. Barker
San Francisco, California

Interest in quadratic equations can be stimulated by the use of a simple rule. Much to the pupils' amazement, it will solve readily all quadratics whose coefficient of x^2 is 1, whether the equation is factorable or not. It will also indicate imaginary roots, and give to the nearest tenth roots of those equations

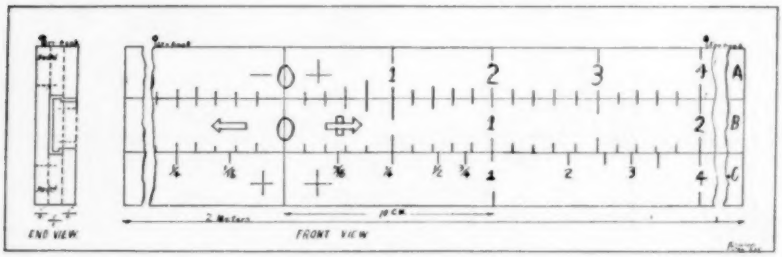


whose coefficient of x^2 is not unity. This ruler can be made quickly and cheaply by any boy taking manual training or woodwork; or it can be made at home. The numbering can be done in the classroom under the teacher's supervision.

The ruler consists of a base on which are fixed an upper scale, A, and a lower scale, C, with room between for the sliding scale, B. The slide contains the numbers N; scale A is $2N$; while scale C is N^2. The dimensions, especially the length, may be made to suit any convenience, but the ones used by the author proved quite expedient, and are shown in the accompanying sketch.

This is the simplest way to make the slide rule; it can be made as elaborate, accurate, and rugged as time and fancy may dictate.

Now as to the numbering. The metric system is the more useful in laying out the three scales needed, because of the ease in marking tenths. First find the midpoints on each scale, and mark it zero. The numbers on the slide *B* are placed 10 cm. apart to the right, or positive, and to the left, or negative, direction from 0. Each centimeter is also marked, to facilitate reading to the nearest tenth, or even closer. (By marking millimeters, the answers can be read with greater accuracy.) The numbers on the upper scale *A* are double those on the slide, and are easily located by using the completed slide. The lower scale *C* contains the squares of the numbers on the slide. So that all the numbers from 1 to 100 may appear on *C*, as well as the perfect squares such as 1, 4, 9, 16, etc., it is best to use a table of square roots, and mark the numbers on the *C* scale below their square roots on the slide. For example, the 2 on scale *C* is placed underneath 1.4, the square root of 2 to the nearest tenth; 3 underneath 1.7; 5 below 2.2, etc. Greater accuracy is possible if the millimeters, or even 5 millimeters, are marked on the slide, but that is not necessary.



The rule is used as follows: reduce the equation to the form $x^2+bx/a+c/a=0$; transpose the numerical term to the right-hand side of the equation; set "0" on the slide underneath the coefficient of x on the upper scale; to the number directly below on the lower or *C* scale add the constant term; find the results (there will be two) on the lower scale; directly above on the slide will be found the answers. For example, solve the equation $x^2+2x-8=0$; transpose $x^2+2x=8$; set 0 on slide underneath +2 on the upper scale; directly beneath the 0 will be found +1 on the lower scale; to this add the constant, $1+8=9$; above the

two nines on the lower scale will be found the two answers, $x=+2$, $x=-4$. Try another equation; $x^2+x-1=0$; transposing $x^2+x=1$; Set slide underneath $+1$ on A scale; to the $\frac{1}{4}$ found directly underneath on C scale add the constant term $+1$; find the result, $1\frac{1}{4}$, on C scale; above one of these will be found $+.6$ on the slide; above the other, -1.6 These answers are correct to the nearest tenth.

When demonstrating the slide rule, or showing the students how to use it, it is best to begin with simple factorable quadratic equations whose coefficient of x^2 is 1.

The rule really solves the equations by completing the square. On scale A is the coefficient of x, slide B gives half this coefficient, while scale C squares one-half the coefficient. To this is added mentally the numerical term, then to the square root of the resulting sum the slide rule adds, and subtracts, one-half the coefficient of x.

OBSERVATIONS OF AIR AND DUST BACTERIA AS A SCIENCE PROJECT

By Arthur H. Bryan

Baltimore City College and University of Maryland, Baltimore, Maryland

One of the most fascinating projects which can be undertaken in the high school biology or general science class or elementary college bacteriology course, is that pertaining to the air, mouth, and dust bacterial flora. Practical applications and research projects in school and civic hygiene can be undertaken as desirable outcomes of the class and laboratory exercises. The writer's classes have undertaken, over a period of years, to make comparative air and dust bacterial flora studies in and around Baltimore schools. The classrooms were first studied under varying pupil loads with natural or artificial ventilation drawing over petri dishes specified amounts of air or dust. The same procedure followed for cafeterias, hallways, gymnasiums, laboratories, shops in new and old schools located down town and in the suburbs. The school bacterial air and dust flora can then be compared with sea, mountain and high altitude aeroplane air, and with public places, such as theatres, market places, pool rooms, street cars, stores, tenement homes, etc. Comparative charts were drawn up which gave some useful information concerning comparative cleanliness.

School and locker rooms have invariably relatively high air and dust bacterial counts. The gymnasiums come next, while classrooms with windows open in the suburbs may have air as free from germs as mountain or sea air. Teachers who, in old buildings insist on having windows closed, temperature high, and humidity low, may see the germ air count run abnormally high when compared with carefully ventilated classrooms.

The students thoroughly enjoy the daily growth observations of the bacterial colonies on the simple nutrient agar petri-dishes and note some of the beautiful colonies, characteristic growths in their "bacterial garden."

A UNIQUE PROPERTY OF THE SPHERICAL HYPERBOLA AND THE SPHERICAL PARABOLA

By A. V. Pershing

Western State Teachers College,
Bowling Green, Kentucky

During a recitation in Spherical Trigonometry a discussion arose as to whether Hyperbolas and Parabolas on a sphere are closed figures or whether the two arms of the Hyperbola pass around the rear of the sphere and connect, thus forming a single closed figure. Soon after, not being satisfied with the conclusions drawn, I painted a few croquet balls with white paint and with the help of my wife carefully constructed a series of hyperbolas and parabolas on their surfaces. All branches were found to be closed figures and in no case did a line cross the rear of the sphere. Two properties were specially noted. All hyperbolas were symmetrical with respect to the center of the hemisphere upon which the branch was graphed. Second, all the parabolas had a major diameter of 90°. In addition it was noted that when the focus of a parabola was moved to the center of a hemisphere it degenerated into a circle and at the same time was fundamentally a parabola by construction.

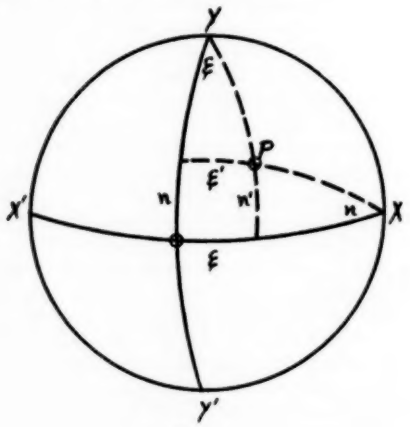


Fig 1

The coordinates in the above figure are taken directly from a pamphlet on Spherical Analytics by Professor D. A. Rothrock of Indiana University.

Let the ordinate of a point P be n and the abscissa ξ. Also let the distance of the point P from the y-axis be ξ' and the distance from the x-axis be n'.

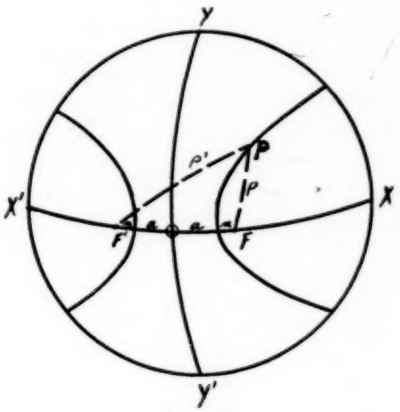


FIG. 2

For the hyperbola we have $\rho'-\rho=2a$, a constant. I.

By construction if P progresses along a branch it closes the curve and returns upon itself always remaining on the same hemisphere, in this case on the right one. The branch being symmetrical to the x-axis reaches its maximum distance from F, the focus when it crosses the x-axis. ρ now lies along the axis of x to the right. ρ' of course lies along the axis of x' to the left. Both lie on the same great circle xx'. Hence

$$\rho'+\rho=2\pi-F'F. \qquad \text{II.}$$

Since

$$F'F=2a+2n \qquad \text{III.}$$

it follows that

$$\rho'+\rho=2\pi-2a-2n. \qquad \text{IV.}$$

Solving I and IV we have $\rho'=\pi-n$ and $\rho=\pi-2a-n$.

To find the distances of P from the center O we must add $(a+n)$ the distance of F' and F from O to each. Doing this we get:

$$D'=\pi-n+a+n=\pi+a$$

$$D=\pi-2a-n+a+n=\pi-a.$$

Either or both these equations show that the point P is distant a to the right of the y-axis produced around to y'. Since the branch is symmetrical to the axis of x and the intersections are at the same distance $\left(\frac{\pi}{2}-a\right)$ from the center of the right hemisphere it is seen by the relation $\rho'-\rho=2a$ that the entire branch is symmetrical with respect to the center of the hemisphere. In fact, the sphere may be reversed and the point now directly opposite O be called O without affecting any of the relative positions of the point P.

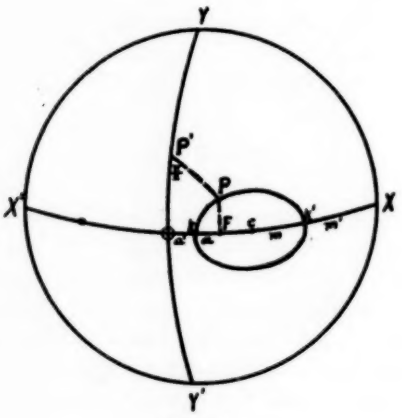


FIG. 3

For a parabola also it may be shown by construction that by keeping $PF=PP'$ where PP' is a normal to the axis yy' produced, we get a closed figure which crosses the x-axis in two points. Call these k and k'. Take C midway between k and k'. By reasoning as in the case of the hyperbola we discover a similar result, namely that the entire parabola is symmetrical with respect to a center C. That this is true will be shown later. Let us first show that its major diameter is $\pi/2$. FO and Fk' produced are normal to yy' produced. Therefore $Fk=Ok$ and $Fk'=k'O'$ where O' is the point directly opposite O for in these positions P' coincides with O or O'. Let $Fk=a$; $kO=a'$; $Fk'=m$; $k'O'=m'$, and we have $a=a'$ and $m=m'$.

But $a'+a+m+m'$ reaches from O to O' and thus $=\pi$.

Hence $2a+2m=\pi$.

Therefore $a+m=\pi/2$.

Since $a+m$ is always the diameter of the parabola; all parabolas must necessarily have their major diameters equal to $\pi/2$.

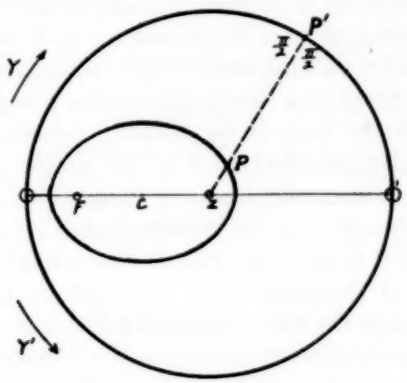


FIG. 4

Let Z be the center of the right-hand hemisphere. Then all segments of great circles drawn from it to the great circle $OYO'Y'$ must be normal to it since Z is the pole of this great circle or yy' axis produced.

Hence $$FP=PP'.$$

Now

$$ZP'=\frac{\pi}{2}$$

$$ZP'=ZP+PP'$$

$$\therefore ZP'=ZP+FP$$

or $$ZP+FP=\frac{\pi}{2}.$$

Let ZP equal r' and FP equal r, and we have $r+r'=\pi/2$ or $r+r'=\overline{C}$, a constant, where $\overline{C}=\pi/2$. But $r+r'=\overline{C}$ is the formula for an ellipse with F and Z as foci. So finally, every parabola on a spherical surface must necessarily be an ellipse also having for its foci the focus of the parabola and the center Z of the hemisphere. In plane geometry we may think of a parabola as the limit of an ellipse. In doing so we imagine that the more distant focus is approaching infinity. Thus by analogy Z on the sphere would represent infinity. Facing the sphere toward the eye with O as the nearest point, Z lies on the horizon if the eye

is at a great distance away, that is if it is so far that we may speak of it as approaching infinity. If the eye is closer than this, i.e., at any normal distance, Z cannot quite be seen. As the eye travels from O toward Z it continually approaches Z but it can never quite see it, no matter how far back the eye may be moved by walking farther and farther away.

We see that to all practical purposes the great circle of which the point O is the pole is by analogy representing our conventional infinity. As the length of the major axis is $\pi/2$, it is always equal to or greater than the distance to Z. It must then either pass through Z when it degenerates into a straight line from O to Z or it must envelope Z. This is equivalent to saying by analogy that the parabola is still open at infinity but that it closes and joins the two arms around on the other side of infinity. It is a parabola because the other focus of the ellipse has been carried out to Z, its infinity, having regard to our analogy.

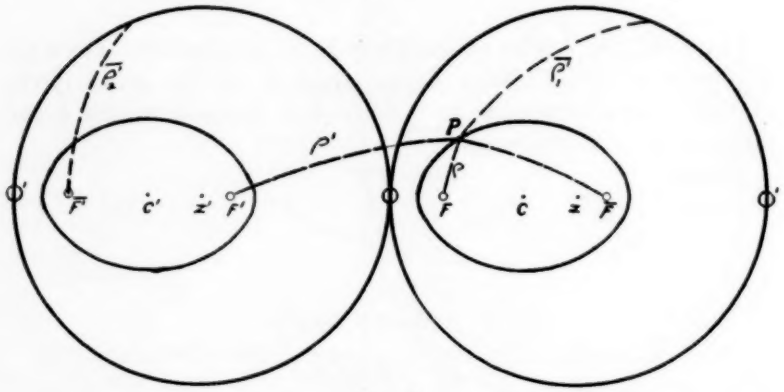


FIG. 5

If it should be carried beyond Z it would no longer be a parabola. It would however still be an ellipse by construction and would be symmetrical with respect to the center C as in the case of the parabola just given. Supposing that these figures are the right branches of the symmetrical hyperbolas first referred to in this paper let us project this branch through the center of the sphere and so obtain the other branch. The projection can be made because the ellipse is a symmetrical figure with respect to its center C. The diameters of each along the x and x' axes are the same. Let us call these major diameters D. Then $\rho+\bar{\rho}=D$, a constant.

Now from the symmetrical relationships involved we have: $\rho'+\bar{\rho}=\pi$, since these segments are arcs of great circles and $\bar{F}$ is the point just opposite the point F'.

Similarly: $\bar{\rho}'+\rho=\pi$, where $\bar{\rho}'=\bar{\rho}_1'+\bar{\rho}_2'$ in the above figure. So we have:

$$\rho'+\bar{\rho}=\pi$$

$$\rho+\bar{\rho}=D$$

$\therefore \rho'-\rho=\pi-D=2a$, the formula for a hyperbola.

Or we may take:

$$\bar{\rho}'+\rho=\pi$$

$$\bar{\rho}+\rho=D$$

$\therefore \bar{\rho}'-\bar{\rho}=\pi-D=2a$, as before.

Since the figures are symmetrical and their major diameters are equal we should have

$$\begin{aligned} 2\pi &= D+2a+D+2a \\ &= 2D+4a \\ &= 2D+2(2a) \end{aligned}$$

but, $2a=\pi-D$, as just shown.

$$\begin{aligned} \therefore 2\pi &= 2D+2(\pi-D) \\ &= 2D+2\pi-2D \\ &= 2\pi, \text{ as it should.} \end{aligned}$$

We saw that the parabola was a special kind of ellipse, i.e. one having a major diameter of $\pi/2$ and with the farther focus at the center of the hemisphere. If we start with this ellipse and carry the farther focus beyond Z we get a hyperbola. Drawing an analogy from plane geometry this is equivalent to saying that if the farther focus is carried to infinity we get a parabola. If it is carried beyond infinity we get a hyperbola.

These hyperbolas really begin with the parabola itself as we may see for, here:

$$\rho'+\bar{\rho}=\pi, \text{ again.}$$

$$\rho+\bar{\rho}=\frac{\pi}{2}$$

$$\therefore \rho'-\rho=\pi-\frac{\pi}{2}$$

$$=\frac{\pi}{2}=2a, \text{ a constant.}$$

This gives $a=\pi/4$ and shows that if a parabola is considered as an arm or branch of a hyperbola, the y-axis must be taken at a distance $\pi/4$ from the nearest intersection of the branch from the right with the x-axis. Since the major diameters of both branches is $\pi/2$, this centers the y-axis midway between the branches as it should.

Thus: $\left(\frac{\pi}{4}+D+\frac{\pi}{4}\right)+\left(\frac{\pi}{4}+D+\frac{\pi}{4}\right)$ should equal 2π. $D=\frac{\pi}{2}$.

$$\therefore \frac{\pi}{4}+\frac{\pi}{2}+\frac{\pi}{4}+\frac{\pi}{4}+\frac{\pi}{2}+\frac{\pi}{4}=4\cdot\frac{\pi}{4}+2\cdot\frac{\pi}{2}$$

giving a sum of 2π, the length of the xx' axis produced.

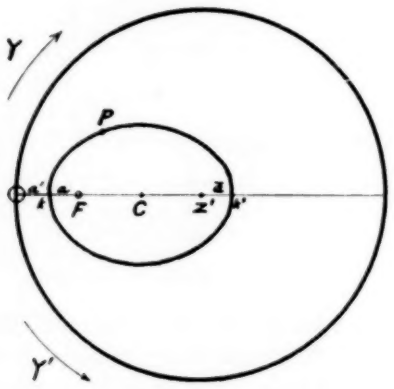


FIG. 6

Let us return to the parabola. Since the parabola is an ellipse having a semi-major axis equal to $\pi/4$: $Ck=Ck'=\pi/4$.
Let Z' be the farther focus. Then $FC=CZ'$ and $a=a'=\bar{a}$.

$$k'k=\frac{\pi}{2}=\bar{a}+kZ'$$

$$\therefore \frac{\pi}{2}=a'+kZ'$$

or

$$O-Z'=\frac{\pi}{2}, \text{ since } \bar{a}=a'.$$

Thus the farther focus of the ellipse-like figure of a parabola is a fixed point, namely the center of the hemisphere on which it is graphed. The other or nearer focus may be varied from O to Z. At O the parabola degenerates into a double segment, namely O–Z. At Z the two foci coincide and we get a circle of radius $\pi/4$. Since this circle is also a parabola we may in addition consider it a branch of a hyperbola having a transverse axis equal to $2a$ or $\pi/2$ as has already been shown.

Here, $$\rho' = \frac{\pi}{4} + 2a = \frac{\pi}{4} + \frac{\pi}{2} = \frac{3\pi}{4}$$

$$\rho = \frac{\pi}{4}$$

$$\therefore 2a = \rho' - \rho = \frac{3\pi}{4} - \frac{\pi}{4} = \frac{\pi}{2}, \text{ as it should.}$$

Here ρ' and ρ do not vary in length as point P describes its path around one arm of the hyperbola.

We might have used Spherical Analytics to have obtained these results. As a case in hand let us prove the result of the last section, that a parabola having its focus moved to Z, the center of its hemisphere, becomes a circle of radius $\pi/4$.

Let us use the following figure and coordinates previously mentioned as having been obtained from a pamphlet on Spherical Analytics by Professor D. A. Rothrock of Indiana University.

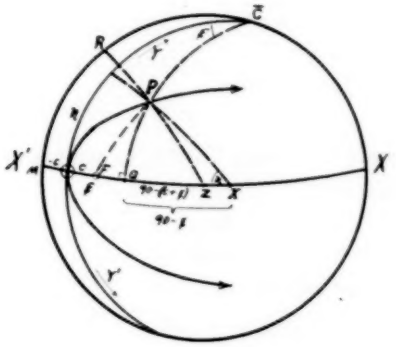


FIG. 7

Here: $PR = PF$.

The coordinates of P are ξ and η. The distances of P from

x-axis and y-axis are η' and ξ'. $PF=D$, is the distance of any point on the parabola to the focus. From the right triangle XPQ we have the relation $\tan \eta' = \cos \xi \tan \eta$. From the right triangle ZPQ we have: $\cos PZ = \sin PR = \cos \eta' \sin (C+\xi)$. From right triangle QPF we have: $\cos PF = \cos D = \cos \eta' \cos (\xi - C)$.

Let us select the last relation, $\cos D$ or $\cos d = \cos \eta' \cos (\xi - C)$, to work with. Then:

$$\cos \eta' = \frac{\cos d}{\cos (C-\xi)}$$

$$\cos^2 \eta' = \frac{\cos^2 d}{\cos^2 (C-\xi)}$$

$$\sec^2 \eta' = \frac{\cos^2 (C-\xi)}{\cos^2 d}$$

$$\tan^2 \eta' = \frac{\cos^2 (C-\xi)}{\cos^2 d} - 1$$

$$\cos^2 \xi \tan^2 \eta = \frac{\cos^2 (C-\xi)}{\cos^2 d} - 1,$$

from the first formula given, namely, $\tan \eta' = \cos \xi \tan \eta$.

$$\frac{\cos^2 (C-\xi)}{\cos^2 d} = (\cos^2 \xi \tan^2 \eta + 1)$$

$$\cos^2 d = \frac{\cos^2 (C-\xi)}{\cos^2 \xi \tan^2 \eta + 1}$$

$$\cos^2 d = \frac{\frac{1}{2}(1+\cos 2 (C-\xi))}{\cos^2 \xi \tan^2 \eta + 1}. \qquad \text{(A)}$$

Let us put down the three formulas first worked out:

(1) $\tan \eta' = \cos \xi \tan \eta$

(2) $\cos PZ = \sin PR = \cos \eta' \sin (C+\xi)$

(3) $\cos PF = \cos D = \cos \eta' \cos (\xi - C)$.

Squaring and adding (2) and (3):

$$1 = \cos^2 \eta' [\sin^2 (\xi + C) + \cos^2 (\xi - C)]$$

since, $\sin PR = \sin PF = \sin D$, as $PR = PF$.

$$\frac{1}{\cos^2 \eta'} = \sec^2 \eta' = 1 + \tan^2 \eta' = \cos^2 C + 4 \sin C \cos C \sin \xi \cos \xi + \sin^2 C$$

or $$1+\tan^2 \eta' = 1+4 \sin C \cos C \sin \xi \cos \xi.$$

$$\therefore \tan^2 \eta' = 4 \sin C \cos C \sin \xi \cos \xi.$$

Substituting $\tan \eta' = \cos \xi \tan \eta$ from (1) we get:

$$\cos^2 \xi \tan^2 \eta = 4 \sin C \cos C \sin \xi \cos \xi$$

$$\tan^2 \eta = 2 (2 \sin C \cos C) \cdot \frac{\sin \xi}{\cos \xi} \cdot \frac{\cos \xi}{\cos \xi}$$

or $$\tan^2 \eta = 2 \sin 2 C \tan \xi,$$

the so-called "Spheric Equation of the Parabola." This equation is derived in three steps in the pamphlet above referred to.

Substitute this value of $\tan^2 \eta$ in (A), and we get:

$$\cos^2 d = \frac{\frac{1}{2}(1+\cos 2 (C-\xi))}{2 \cos^2 \xi \sin 2C \tan \xi + 1}$$

$$\cos^2 d = \frac{1+\cos 2 (C-\xi)}{4 \cos \xi \sin \xi \sin 2C + 2}$$

$$\cos^2 d = \frac{1+\cos (2C-2\xi)}{2+2 \sin 2C \sin 2\xi}$$

$$\cos^2 d = \tfrac{1}{2} \cdot \frac{1+\cos (2C-2\xi)}{1+\sin 2C \sin 2\xi}.$$

Now F was to be moved to the center of the hemisphere Z. $FM = 2C$ from the figure since $FM = ZM$, remembering that F and Z coincide.

Then: $$\cos^2 d = \tfrac{1}{2} \cdot \frac{1+\cos\left(\frac{\pi}{2}-2\xi\right)}{1+\sin \frac{\pi}{2} \sin 2\xi}$$

$$= \tfrac{1}{2} \cdot \frac{(1+\sin 2\xi)}{(1+\sin 2\xi)}$$

$$\therefore \cos^2 d = \tfrac{1}{2}, \text{ or } \cos d = \frac{1}{\sqrt{2}}.$$

Hence;

$$d = \cos^{-1} \frac{1}{\sqrt{2}},$$

a constant, showing that d, the distance of the point P from the focus F is constant. Hence the figure is a circle.

$$\cos^{-1}\frac{1}{\sqrt{2}}=45^\circ$$

$$\therefore d=\frac{\pi}{4},$$

giving the diameter of the parabola as, $2d=\pi/2$ or 90° and the radius of the circle as $\pi/4$.

In this case as in all others the major diameter of the parabola is found to be 90° in length.

In his *Analytic Geometry of Three Dimensions* Salmon devotes a chapter to these "sphero-conics." (Fifth edition, 1912; Vol. 1, p. 249.) He points out that such a sphero-conic is the curve in which any quadric cone cuts a sphere with its center at the vertex of the cone. From this point of view all the properties follow readily.

Finally, we wish to express our appreciation to Professor A. L. Foley for his helpful criticism and to James H. Coon for the construction of the several drawings referred to above.

BETTER DENTAL DIAGNOSIS

The high intensity mercury vapor lamp is being tried out in New York City as an aid for better dental diagnosis. Instead of examining the mouth in daylight or by the light from ordinary electric lamps, Dr. M. M. Scheman of Brooklyn is using the ghostly blue-green rays from the mercury lights in his practice.

Many people are familiar with the almost sickly greenish-yellow color to which a person's face turns under the mercury light. Dr. Scheman finds that the teeth appear whiter and the mucous membrane of the mouth looks dark purple in the same rays. Mouth diagnosis is aided by bringing about a sharper contrast between healthy and unhealthy tissues, he finds.

Besides the apparent greater whitness of healthy teeth, it has been found that there is a slight characteristic fluorescence. Tartar and film deposits on the teeth do not fluoresce in this fashion, and, as a result, stand out sharply in contrast to increased whiteness of the healthy enamel.

Since the mucous membrane tissues turn to their deep purple color, there is considerable contrast between them and the mouth disturbances which retain their normal appearance. Ramifications of the blood vessels, it is found, are more clearly defined than under normal illumination. Pathological disturbances in the mouth such as abscesses, conditions of inflammation in and about the necks of teeth and the mucous membranes are sharply accentuated by marked changes of color—*Science Service.*

THE BOTANICAL MUSEUM

PART I

By Edwin D. Hull
Hull Botanical House, Gary, Indiana

This paper is designed to aid teachers in the formation of a botanical museum, either in entirety, or in the selection of specimens according to need. The first part is devoted to the plant kingdom, then follows a discussion of plant organs, and finally a brief account of ecological groups.

Most specimens are very well mounted dry; some will show up much better in a liquid medium. This will be noted later in a discussion of material. Should dry specimens be attacked by insects they can be soaked in formalin for 24 hours and then re-dried.

Probably the best general medium for mounting specimens is the Riker Specimen Mount, in which the plants are placed in a cardboard box of one inch in depth, resting on cotton and protected by glass on top. A ring in the back of the mount will permit the preparations to be hung on a wall if desired. A label is also provided on the back. Specimens can be removed. This mount will take care of all flat specimens, and those of moderate thickness. Flat specimens can be cared for in the Riker Botanical Mount, which is much like the above except that it lacks depth, and the preparation is sealed.

For dry specimens of considerable thickness, and fluid material, jars will be needed. The best are the regular museum jars of clear white glass and with glass stoppers, but these are very expensive, and seem hardly suited to the wear and tear of the school room. It is like publishing school books in de luxe editions. Another good museum jar is one which is sealed with cement after the specimens have been placed therein. In this, however, material cannot be removed. Both types of jar can be had of dealers in school apparatus. On the market also are various types of specimen jars, the best in looks and convenience being those with Amerseal tops. These are far cheaper than the museum jars and are quite satisfactory.

Many specimens can be bought of supply houses, but many will need to be made, and some teachers may prefer to make them all. For dry preparations the plants can be pressed in the usual way, or in many cases, as in woody stems, better left

without pressing. For flat specimens a mount similar to the Riker Botanical Mount is easily made. There will be required cardboard, cotton, and binding paper, as passe partout, or still better the much stronger cloth tape. Cut the cardboard to the desired size, then spread over it a layer of cotton, and arrange the plants thereon. Cut the binding material to the proper length, paste first on the glass, leaving a considerable margin free, and allow to dry for a few minutes. Lay the glass over the specimens and complete the binding. If mounts are to be hung on a wall insert in the cardboard before arranging the cotton and specimens two paper fasteners, to which attach a loop of cord or fine wire. A little experience should result in very neat and serviceable mounts. The mounting of fluid material is more complicated. Needed besides the jars are glass slips to fit them, a four percent solution of formalin, some gelatin and some thread. The slips can be cut by the preparator or bought at the hardware store for a few cents each. The formalin can be purchased in a forty percent solution at the drug store, to this should be added twenty-four parts of water to one part of formalin. The gelatin is the sort to be had at every grocery. To mount place the specimens previously soaked in formalin and then allowed nearly to dry on the glass slips and glue them securely with gelatin, melted by heating to a moderate temperature. A drop of gelatin here and there will be quite enough for delicate specimens, but the others in addition should be firmly tied with thread. Allow the gelatin to cool, and then immerse the slip in the jar of formalin. Labels can be glued on the slip with gelatin, or they can be attached to the outside of the jar.

Many plants can be kept in a living condition, and these may very well be included in a museum collection. Some will require aquaria (See SCHOOL SCIENCE AND MATHEMATICS 32: 143–148. 1932), others terraria (SS & M 34: 372–379. 1934) or a Wardian Case (SS & M 34: 720–723. 1934). If a greenhouse is available then so much the better. For living plants, especially those under cultivation, consult catalogues of seedsmen and nurserymen, copies of which should be sent on request, or they can perhaps be seen at the local library. In this connection Bailey's Manual of Cultivated Plants will be of the greatest value.

The Naturalists' Directory, published by S. Cassino, Salem, Massachusetts, may be very useful in securing specimens, especially through exchange.

In selecting specimens for preservation it may be well to have

a manual covering the flora of the region in which the school is located, and other manuals may be of use.

PLANT KINGDOM

Plant Kingdom: A very instructive preparation giving a general survey of the entire plant kingdom can be made by showing side by side representatives of the larger groups of plants, as the thallophytes, illustrated by an alga and a fungus, the bryophytes including a liverwort and a moss, the pteridophytes showing a true fern and two common fern allies, *Equisetum* and *Lycopodium*, and the spermatophytes, with a typical gymnosperm and a typical angiosperm. This dry preparation is best shown in a Riker Specimen Mount.

THALLOPHYTES

Myxomycetes and Bacteria, often included here, are not treated, since modern knowledge seems to indicate that these do not belong to the plant kingdom.

Algae, Blue Green: Three common forms are suitable for a museum preparation, namely, *Nostoc*, occurring as large nodules in water or on wet ground, *Rivularia*, nodules on the stems and leaves of water plants, and *Oscillatoria*, occurring in mats in water or on damp ground. This is a formalin preparation. *Nostoc* and *Oscillatoria* can probably be kept alive.

Algae, Green: Suitable fresh-water forms include *Pleurococcus*, unicellular, best shown in situ on the bark of a tree, *Hydrodictyon* (Water Net), *Cladophora*, a much branched filamentous form, *Oedogonium*, an attached single filament, *Spirogyra* (Water Silk), a free single filament, and *Chara* (Stonewort), a large branching form. *Chara* is easily kept in the aquarium, rooted in sand at the bottom. Of marine species *Ulva* (Sea Lettuce), whose form is indicated by the common name, is valuable. *Penicillus dumentosus* (Merman's Shaving Brush), with a thick, short stalk and a dense tuft of filaments at the upper end, is very interesting. It occurs on the Florida coast and perhaps elsewhere. Another interesting species is *Dasycladus occidentalis*, a small tufted form, with two sorts of branches, sterile and fertile; in the fertile branch the spores are very conspicuous. It grows in the same habitat as *Penicillus*. Other marine green algae can probably be had of dealers in biological supplies. All the forms mentioned will be much better shown dry. Simply float out in water on a slip of paper, place over them a sheet of waxed paper,

and dry under pressure as in the case of herbarium specimens.

Algae, Brown: These are mostly of large size, some of them the largest of all algae, and nearly all are marine. The Diatoms are partly fresh-water. Those which are attached to stones in streams in the form of long filaments are best. Marine form include *Ascophyllum nodosum* with air bladders somewhat resembling the nodes on stems, *Chordaria*, a cord-like form, *Ectocarpus*, a finely branched filamentous form, *Laminaria*, with long stipe and blade, *Postelsia* (Sea Palm), appearing like a miniature palm, *Fucus* (Rockweed), the most studied form, and *Sargassum* (Gulfweed), with leaf-like branches and berry-like floats. *Ascophyllum* often can be found in the fish-market, being used as packing for transportation from the sea. All these forms can be mounted dry, but they will be displayed better as jar material. Formalin seems to keep their color perfectly.

Algae, Red: These are mostly smaller than the Brown Algae, but like them are nearly all marine. *Batrachospermum* is a small filamentous form occurring in gelatinous masses in fresh water. It is as green as any of the Green Algae. *Polysiphonia* is the most studied, a small much branched form. *Chondrus crispus* (Irish Moss), an edible species, will be of interest, likewise *Nemalion*, a cord-like somewhat branching species. Other forms can probably be had of dealers. All will be best mounted dry.

Fungi, Alga-like: This group includes only a few forms suitable for the museum, such as *Rhizopus* (Bread Mold), which can be grown on a slip of paper smeared with some nutritive medium such as gelatin, *Saprolegnia* (Water Mold), found in ditches in early spring before the weather gets too warm, occurring on insects and dead fish, and easily cultivated by placing insects or small dead fish in pond water in a vessel, the water being kept rather cool, and *Albugo* (Blister Rust), a common parasite on the common Shepherd's Purse. These are much better displayed in a jar.

Fungi, Sac: This is a rather large group. Saprophytic forms include *Morchella* (Morel), an edible species, found in woods, etc., in early spring, *Peziza* (Cup Fungus), comprising a number of plants with shallow cups, some of them brilliantly colored, most abundant in spring, *Tuber* (Truffle), an underground form, famous as a delicacy in some parts of Europe, and not unknown in America, *Penicillium* (Green Mildew) and *Aspergillus* (Yellow Mildew), both found in abundance on various damp substances, and cultivated as in the Bread Mold. Parasites include

the Powdery Mildews, found especially in late fall on various leaves, such as *Microsphaera* (Lilac Mildew), *Erysiphe*, with many species, the most common one found on one of the Knotweeds (*Polygonum aviculare*), *Uncinula* (Willow Mildew), and *Phyllactinia* (Oak Mildew). Black dots on the leaves will indicate the fruiting stage. Dry the leaves under light pressure. *Plowrightia* (Black Knot) will often be found in abundance on cherry trees. *Claviceps* (Grain Ergot) in several species will be found in the spikes of various grains, the fruiting bodies having the shape of the grain, but much larger, and black in color. All these are best shown dry, and as some of them are thick a Riker Specimen Mount is to be preferred.

Lichens: There are three types of these, *crustose*, forming thin crusts on rocks, and firmly imbedded in them, so that it is better to take a fragment of the rock instead of trying to detach the specimen, *foliose*, leafy in appearance, and not near so firmly attached to the substratum, found in woods, etc., and *fruticose*, usually with slender branching bodies, and cup-like fruit. *Cladonia*, a genus including the Reindeer Lichen, and one very common species (*C. cornucopioides*) belong here. *Usnea* (Bearded Lichen) is perhaps the best of this type, depending from the trunks and branches of trees, and with very conspicuous fruiting bodies. These will show very well dry, or perhaps better in fluid.

Fungi, Basidia: This large group can most conveniently be treated in several subdivisions. *Ustilago* (Smut of Grain) infests many members of the Grass Family. Particularly noticeable is *Ustilago Maydis* (Corn Smut). Specimens can be mounted dry or in fluid in Riker Specimen Mount or jar. *Puccinia* (Rust of Grain) in many species likewise attacks various grasses. Most noticeable is the Wheat Rust (*P. graminis*), which in its uredospore stage occurs on leaves of wheat (summer), in a later teleutospore stage on wheat stubble (autumn), and in an aecidiospore stage on a very different type of host, the Common Barberry (*Berberis vulgaris*) (spring). All three types should be shown, dry. The Common Barberry has been destroyed over a good part of the country, but is still common perhaps in places, as in some parts of New England, and if it cannot be collected dealers can usually supply the leaves. *Clavaria* (Coral Fungus), whose appearance is indicated by the common name, can often be found in abundance in woods in autumn. Preserve dry or in fluid. The Pore Fungi (*Polyporaceae*) include some very common

forms, the Bracket Pore Fungi being the most common, these being both annual and perennial. *Polyporus* is the annual type, in the form of brackets on the trunks of trees, and without stalks. *P. sulphureus* (Sulphur Fungus), with the color of sulphur, is the most conspicuous form. It is best preserved dry after soaking in formalin for 24 hours to avoid insect pests. *Fomes* is the perennial type, one species, *F. cinnabarinum*, found in autumn on fallen logs, etc., is a very conspicuous reddish species. Treat as in *Polyporus*. Both species are rather thick and will require a specimen mount or jar. *Boletus* is a pore fungus, but with a definite stalk, in contrast to the other two, found on logs, etc. This will show better in formalin. The Tooth Fungi (*Hydnaceae*) occur in either the bracket or mushroom form. The Gill Fungi (*Agaricaceae*) form by far the largest group, with the habit of the Tooth Fungi. *Agaricus campestris* (Field Mushroom), an edible species, can be obtained at the grocery; the others will have to be collected, usually in late summer or fall. Formalin is recommended for both the Gill and the Tooth Fungi. The Puffballs (*Lycoperdales*) are found in two types, one, represented by the common *Lycoperdon pyriforme*, pear-shaped, discharging its spores through a small opening in the top, while in the other, *Geaster* (Earth Star), the outer layer splits before the spores are shed. *Lycoperdon* is found commonly in woods, *Geaster* in sandy places. Both can be preserved dry or in formalin. The Nest Fungi (*Nidulariales*) can often be found in autumn on logs, etc. The resemblance to a bird's nest is very striking. Preserve dry in jar or specimen mount.

Three minor orders of Basidia Fungi may occasionally be seen. These are the Carrion Fungi (*Phallales*), which decay so rapidly that it is better to take a jar of formalin into the field, and preserve the plants at once, the Ear Fungi (*Auriculariales*) and the Jelly Fungi (*Tremellales*), both of these best preserved in formalin.

BRYOPHYTES

Liverworts: A good exhibit will include the following genera: *Riccia*, *Marchantia*, *Pellia*, *Porella* (Leafy Liverwort), and *Anthoceros* (Horned Liverwort). A formalin preparation is by far the best. *Riccia*, both *R. fluitans* and *R. natans*, can be grown in aquaria, the former under the name of Crystalwort being sold by a number of dealers in aquatics. The other genera, with perhaps the exception of *Porella* which grows on tree trunks, can

be kept in terraria. Soil which has been burned over is especially good for *Marchantia*. Closely related to *Marchantia* is a woodland and bog species, *Conocephalus*, which is very easily grown. A Liverwort life-history is valuable, the one usually chosen for this purpose being *Marchantia*. A complete life-history will include a thallus with cupules, an antheridial plant, an archegonial plant with the archegonial branches still closely appressed to the thallus, and an archegonial plant with mature sporophytes, the branches being well raised into the air. This, too, should be placed in formalin.

Mosses: A collection should include *Sphagnum* (Bog Moss), *Hypnum* (Golden Moss), *Polytrichum* (Hair-Cap Moss), *Climacium* (Pine-Tree Moss), *Leucobryum* (White Moss), *Ceratodon* (Purple-stemmed Moss), *Fontinalis* (Aquatic Moss), *Bryum*, *Funaria*, and *Mnium*. *Tetraphis*, which bears gemmae, might also be added, and other forms too. These can be preserved dry with moderate pressure, although they will show better in formalin. The life-history of a moss makes a desirable preparation, *Polytrichum commune*, a large species, being the most suitable. There should be shown a male plant with antheridia, a female plant with archegonia, a female plant with young sporophyte, the calyptra being present, and an old sporophyte in which the calyptra has fallen. Protonema should also be shown; it will probably be necessary to use another species for this. Protonema can be found in abundance in most localities, such as the north side of buildings, etc. This life-history will look better in formalin. *Fontinalis* is easily kept in aquaria, and is offered by some dealers in aquatics. *Sphagnum* does well in the bog terrarium, and the others in the woodland terrarium.

PTERIDOPHYTES

All these, with the exception of certain stages in the life-history, are perfectly satisfactory as dry mounts.

Lycopodium: It is well to arrange these with reference to the evolution of the strobilus, that is, *L. Selago*, with sporangia in the axils of all the foliage leaves, *L. lucidulum*, with sporangia in the axils of foliage leaves, but in groups of leaves alternating with groups of sterile leaves, *L. inundatum*, with a distinct spike, but the sporophylls resembling ordinary leaves, *L. obscurum dendroideum* or *L. annotinum*, with the sporophylls as scale-like bracts, the fertile branches leafy up to the spikes, and *L. clavatum*, with sporophylls scale-like, and the fertile branches modi-

fied below the spikes into distinct peduncles. The gametophytes of some species have been found in America, and a life-history preparation can be made, showing the mature sporophyte in fruiting stage, a gametophyte with sex organs, and a gametophyte with young sporophyte. The gametophytes will be better shown in formalin; they can be placed in vials in a Riker Specimen Mount along with the dry sporophyte, or all three can be mounted in formalin in a jar. In general, species of this genus are not easily kept alive, though *L. lucidulum* will live for some time in the woodland terrarium, and gemmae are produced in abundance which will grow slowly if removed from the plant and placed on the surface of the soil.

Selaginella: Two native species will be all that is needed, *S. apus,* a small creeping form of wet places, and *S. rupestris,* a larger and tufted form of rocks and sand dunes. Mount dry or in formalin. Both these species will live for some time in terraria, although cultivated forms will do much better, especially the creeping *S. Kraussiana,* the commonest greenhouse species, and the erect *S. Emmeliana. S. lepidophylla,* the Resurrection Plant, native of the southwest, can be had of dealers in curiosities, or possibly from nurserymen. It is a tufted species with rosette habit.

Isoetes: The Quillworts are small aquatic or marsh plants of many species, and widely distributed but hard to find, though *L. lacustris* of the south can be had of some dealers, and dried under pressure or kept in the aquarium.

Equisetum: Most valuable are *E. arvense* (Common or Field Horsetail), with both sterile and fertile shoots, *E. fluviatile* (Pipes), with fertile shoots only, these deciduous, and *E. hyemale* (Winter Horsetail), with fertile evergreen shoots. A life-history can be arranged. There are both male and female prothallia in this genus; they can be placed in vials of formalin along with the dried sporophyte in a specimen mount, or the entire preparation can be mounted in a jar. It hardly seems worth while to attempt keeping *Equisetum* alive.

True Ferns: The group is so large that only the more important genera can be indicated. These are: *Osmunda* (Flowering Fern), with either separate fertile fronds, or a single type of frond, partly sterile and partly fertile. In all cases the fertile and sterile portions differ very much. *Polypodium* (Polypody) with sori naked on the back of frond. Adiantum (Maidenhair) with sori marginal, protected by the infolded edge of the leaf which

forms an indusium. *Pteris* (Brake) with sori as in *Adiantum* except that they are continuous. *Woodwardia* (Chain Fern) with sori arranged in chain-like rows on the back of the frond. *Asplenium* (Spleenwort) with sori on back of frond, provided with distinct indusium, which is attached along one edge. *Camptosorus* (Walking Fern) with entire leaves, sori about as in *Asplenium*. *Polystichum* (Christmas Fern) with fronds fruiting only in the upper portion, the fertile pinnules being much contracted, indusium orbicular, peltate. *Aspidium* (Shield Fern), sori borne on the backs of unmodified fronds, indusium mostly reniform though attached at center. *Cystopteris* (Bladder Fern) with indusium attached at the side. *C. bulbifera* bears numerous bulbils on the under side of the fronds, and is very interesting. *Woodsia*, small plants with cup-like indusia. *Onoclea* (Sensitive and Ostrich Ferns) with sterile fronds and fertile fronds with berry-like pinnules.

All of these ferns can be kept alive. *Camptosorus* does not seem to thrive without limestone; this can be supplied by inserting a few small pieces of rock in the soil. Several ferns, grown as house or conservatory plants, can be procured from florists' shops or from nurserymen. Such are: *Scolopendrium* (Hart's Tongue Fern), *Cyrtomium* (House Holly Fern), *Nephrolepis* (Sword Fern, including the common Boston Fern), *Adiantum* (Maidenhair Fern), *Platycerium* (Staghorn Fern), *Asplenium nidus* (Bird's Nest Fern), and *Pteris* (Brake). *Ceratopteris* is an aquatic fern, to be had of dealers in aquatics, and easily grown in an aquarium or pool provided with an inch or two of rich soil. A moist atmosphere will be needed.

Water Ferns: The three common genera are *Salvinia*, *Azolla*, and *Marsilea*, the first two floating, all of which can be procured from dealers, or in many localities they can be collected. If fruiting material is desired they will probably have to be bought of supply houses. They are easily grown if a moist atmosphere is provided, and some rich soil. They are not likely to do well in ordinary uncovered aquaria.

Ophioglossum: O. vulgatum is a widely distributed species, but not common except in rare instances. It will probably have to be purchased from dealers in school supplies.

Botrychium: Of the several species of Moonwort a simple form such as *B. Lunaria* and a more elaborate species, as *B. virginianum*, should be included.

SPERMATOPHYTES (GYMNOSPERMS)

Cycads: Zamia is the most available species, found in southern Florida. A complete preparation would show an entire young plant, an adult leaf, a staminate cone with isolated sporophyll, and an ovulate cone in the same manner, all to be mounted dry in Riker Mount, although, unless cut longitudinally the cones may require a jar. This plant can probably be kept alive in the greenhouse or Wardian Case, certainly not in the ordinary schoolroom.

Ginkgo: G. biloba (Maidenhair Tree) is becoming common in street planting, etc., and certain portions of the plant would be available in many localities. I have never seen it fruiting, however, except in the Botanic Garden of Harvard University, and in the Missouri Botanical Garden at St. Louis. If available there should be shown a leaf, a twig in winter, this being a deciduous form, a cluster of staminate cones, young and mature pistillate cones, and a seed, all dry with the exception of the plum-like mature pistillate cone, best shown in formalin. Specimens that cannot be collected can probably be had of dealers.

Conifers: A life-history of the commonest genus, *Pinus*, will be found very helpful. This would include a cluster of staminate cones, three stages of the pistillate cones, that is, at the time of fertilization, in the second year, and when mature, seed, a seedling at time of germination with numerous cotyledons, a seedling at the end of the first year with the cotyledons still functioning and isolated foliage leaves, and a seedling at the close of the second year with withered cotyledons, the isolated leaves of the first year, and the fascicled leaves of the second year. All can be mounted dry in Riker Mount. Fruiting branches of common genera are well shown in formalin in jars; such would include *Pinis*, a soft pine as *P. Strobus*, and a hard pine as *P. sylvestris*, *Larix* (Larch), *Abies* (Fir), *Picea* (Spruce), *Tsuga* (Hemlock), *Taxodium* (Bald Cypress), *Sequoia* (Redwood), *Juniperus* (Juniper), *Thuya* (Arbor Vitae), and *Taxus* (Yew).

SPERMATOPHYTES (ANGIOSPERMS. MONOCOTYLEDONS)

There will be indicated here only the principal families with their most important genera. Those wishing to go further into the subject should make use of the various manuals. All can be prepared as dry mounts, unless otherwise noted.

Cattail Family (*Typhaceae*): *Typha* is easily available to most.

Two common kinds are often found together, these are *T. latifolia* and *T. angustifolia;* the latter with an interval between the staminate and pistillate flowers is perhaps the best.

Pondweed F. (*Najadaceae*): Species of *Potamogeton* (Pondweed) are found in quiet water. Two should be included, one with floating leaves, as *P. americanus,* and one with all the leaves submerged, as the introduced Old World *P. crispus. Zostera marina* (Eel Grass) can be found in shallow water along the coast. Many pondweeds are readily kept in aquaria.

Water-Plantain F. (*Alismaceae*): *Sagittaria* (Arrowhead) with several species is common in swampy situations. *Alisma* (Water Plantain) is common in a similar habitat. *Sagittaria sinensis* and *S. subulata* are the best for living specimens. They are easily grown in aquaria, but will probably have to be bought from dealers in aquatics.

Frog's Bit F. (*Hydrocharitaceae*): *Elodea* (Waterweed) and *Vallisneria* (Tape Grass), common in quiet water, can often be collected, or can be bought of dealers in aquatics. Both are easily kept in the aquarium, likewise Hydrocharis (Frog's Bit), to be had of dealers if unable to collect.

Grass F. (*Gramineae*): Common genera are *Digitaria* (Finger Grass), a common weed, *Panicum* (Panic Grass), including native plants and introduced weeds, *Echinochloa* (Barnyard Grass), a weed, *Setaria* (Foxtail), likewise a common weed, *Cenchrus* (Sandbur), a pest in sandy soil, *Zizania* (Indian Rice), a native plant of swamps, *Hierochloe* (Vanilla Grass), a fragrant native, *Stipa* (Porcupine Grass), of plains, prairies and woods, *Calomovilfa* (Dune Grass), with habitat indicated by the common name, an important sand binder like the one following, which is *Ammophila* (Sand Reed), *Spartina,* a common marsh grass, *Phragmites* (Reed), a tall very handsome grass of swamps, *Poa* (Meadow Grass), with many common species both native and introduced, *Bromus,* (Brome Grass), with nodding fruit, common in waste places, *Hordeum* (Squirrel Tail Grass), a common weed, and *Elymus* (Wild Rye), of sandy places open or shaded, prairies, etc. Probably all of them can be kept in greenhouses or terraria for some time; many of them are annual and must be grown from seed. Many economic plants belong here, and can be divided into five classes, as grains, forage grasses, weeds, sand binders, and ornamentals. A very interesting preparation can be made showing the five divisions.

Sedge F. (*Cyperaceae*): *Cyperus* is common in wet or some-

times dry ground. *Eleocharis* (Spike Rush) can be found in water or wet ground. *Carex* is by far the largest genus, found abundantly in swamps or occasionally in woods. *Cyperus umbellatus* (Umbrella Plant) has long been a favorite house plant, and is readily grown even in the schoolroom if provided with a soil constantly wet. *C. esculentus* (Chufa) is sometimes cultivated for its edible tubers; it is a native of the northern hemisphere. Other species of the family may be grown in terraria. One species of *Eleocharis* (*E. acicularis*) is a fair aquarium plant, and there may be others.

Palm F. (*Palmaceae*): These will probably have to be shown mostly as living specimens. Two at least should be included, a fan palm such as *Livistoma* or *Chamaerops*, and a feather palm as *Howea* or *Phoenix*. These can be had of dealers. *Phoenix dactylifera* (Date Palm) is readily grown from seed, though it will remain in a juvenile condition for a long time. Seeds have been germinated within a week if kept continuously warm and moist. The date is now in cultivation in parts of the United States, and flowers and fresh fruit may be available. The Cocoanut (*Cocos nucifera*) can, of course, be obtained most anywhere, sometimes with husk.

Arum F. (*Araceae*): Common genera are *Arisaema* (Jack-in-the-Pulpit), *Symplocarpus* (Skunk Cabbage) and *Acorus* (Sweet Flag). Easily kept alive are *Caladium*, *Zantedeschia* (Calla), *Philodendron*, and *Pistia* (Water Lettuce), the last an aquarium plant.

Duckweed F. (*Lemnaceae*): Four of these tiny aquatic plants will be needed for a complete preparation, *Spirodela* with several roots, *Lemna* with a single root, *Wolffia*, a minute rootless grain, and *Wolffiella* with rootless sickle-shaped body.

Spiderwort F. (*Commelinaceae*): Species of *Commelina* (Day Flower) will be found as weeds or native in woods; the native *Tradescantia* is likewise very common. *Zebrina pendula* and *Tradescantia fluminensis*, both known as Wandering Jew, the former with striped leaves, are very common house plants.

Rush F. (*Juncaceae*): Species of *Juncus* (Rush) are very common in swamps and wet places, and *Luzula* (Wood Rush) can be found in open woods.

Lily F. (*Liliaceae*): *Uvularia* and *Oakesia* (Bellwort) are common spring flowers in woods. Wild species of *Allium* (Onion) are likewise common. *A. tricoccum* (Wild Leek) is especially interesting, the leaves appearing in early spring, and disappear-

ing before the flowers are produced. Many species of brilliantly flowered Alliums are found in the western U. S. *Lilium* (Lily) is common in the wild and in cultivation. *Fritillaria* (Checkered Lily) is common in many species in the western U. S., and the European *F. meleagris* is often cultivated. *Calochortus* (Butterfly Lily), which occupies the same place in the New World as the tulips in the Old World, has about fifty species in the western U. S. Bulbs of many species grow readily in pots, and the plants can be pressed when they bloom. Erythronium (Trout Lily) has two common forms in the eastern U. S. and many more in the west. *E. Hartwegii* of the west is readily grown in terraria. *Tulipa* (Tulip) has a wild introduced form in the east, the yellow flowered *T. sylvestris*. The common garden tulips are often too much modified to be of much use as botanical specimens, but some closely resemble the wild forms, as *T. Clusiana* (Lady Tulip). *Yucca* (Spanish Bayonet) is common in dry regions, and one form is abundantly planted. *Asparagus* contains the common garden vegetable, *A. officinalis*, the so-called Asparagus Ferns, especially *A. Sprengeri*, easily grown in the school room, and the Greenhouse Smilax (*A. asparagoides*). *Trillium* with many species is common in the U. S. Other genera common in woods are *Clintonia*, *Maianthemum* (False Lily-of-the-Valley), *Polygonatum* (Solomon's Seal), and *Smilacina* (False Solomon's Seal). The plant in this family of greatest economic importance is the Onion, of which there are many varieties, as *Allium sativum* (Garlic), *A. Porrum* (Leek), *A. Cepa* (the common Onion with several forms), and *A. Schoenoprasum* (Chive).

Amaryllis F. (*Amaryllidaceae*): The great majority of these are cultivated genera as *Amaryllis*, *Hippeastrum* (including the forms commonly called "Amaryllis"), *Narcissus* with many forms, *Agave americana* (Century Plant), and *Polianthes* (Tuberose). All of these can be grown in pots. *Hypoxis* (Star Grass) is a common form of woods and meadows in the eastern and central states. It can be grown in the terrarium.

Iris F. (*Iridaceae*): Wild species of *Iris* can be found in many places; there are likewise many cultivated forms. *Belamcanda chinensis* (Blackberry Lily) is a curious form with blackberry-like fruits, easily grown in gardens. *Gladiolus* and *Crocus* are well-known cultivated plants. *Sisyrinchium* (Blue-eyed Grass) with several species is a common native in many places.

Orchid F. (*Orchidaceae*): Native genera most likely to be found

are *Cypripedium* (Lady's Slipper), *Orchis*, *Habenaria* (Rein Orchis), *Pogonia*, *Calopogon* (Grass Pink), *Spiranthes* (Ladies' Tresses), *Liparis* (Twayblade), and *Corallorrhiza* (Coral Root), the last a parasite and destitute of any green coloration. There are many greenhouse species, but it is probably not worth while to attempt their cultivation; perhaps *Cordula* (Glasshouse Lady's Slipper) is the easiest. Most of the wild species will do fairly well in terraria, except the parasitic ones. The economic *Vanilla* belongs here; the pod from which the extract is made can perhaps be had from manufacturers of the product.

ANGIOSPERMS (DICOTYLEDONS. ARCHICHLAMYDEAE)

Willow F. (*Salicaceae*): The two genera are *Salix* (Willow) and *Populus* (Poplar), all woody plants. A preparation should show a twig in winter condition, staminate and pistillate catkins, leaves, and fruit.

Walnut F. (*Juglandaceae*): The two common genera are *Juglans* (Walnut) and *Carya* (Hickory), likewise woody plants. Of the walnuts *J. cinerea* (Butternut), and *J. nigra* (Black Walnut) are more or less common in the wild, while *J. regia* (English Walnut) is common in the markets. An instructive preparation can be made showing twigs in winter and leaves of the wild species, and nuts of all three, and the flowers of one, the staminate being in catkins, while the pistillate are solitary or several together, though hardly to be called a catkin. *Carya* can be shown likewise, the common economic form being *C. Pecan* (Pecan).

Birch F. (*Betulaceae*): Common genera are *Corylus* (Hazelnut), *Ostrya* (Hop Hornbeam), *Carpinus* (Ironwood), *Betula* (Birch), and *Alnus* (Alder), all trees or shrubs, and all more or less common in woods and swamps. A preparation should show a twig in winter, staminate and pistillate catkins, and leaves and fruit.

Beech F. (*Fagaceae*): Common genera are *Fagus* (Beech), *Castanea* (Chestnut) and *Quercus* (Oak). *Fagus grandifolia* (American Beech) is common in the eastern U. S., while several forms of *F. sylvatica* (European Beech) are in cultivation. *Castanea dentata* (American Chestnut) has been nearly exterminated by a blight, but the much smaller *C. pumila* (Chinquapin) is common in the south, while fruit of *C. sativa* (Eurasian Chestnut) can be had at least in the larger markets. Specimens of *Quercus* can be had in most localities. Preparations can

be made as for the above; in this family the pistillate flowers are not in catkins. An excellent study in classification can be made by arranging together leaves and fruit (including cups) of several species of oak. Especially desirable species are *Q. alba* (White Oak), *Q. macrocarpa* (Bur O.), *Q. Prinus* (Chestnut O.), *Q. virginiana* (Live O.), *Q. rubra* or *Q. velutina* (Red O. or Black O.), *Q. marilandica* (Black Jack O.), and *Q. imbricaria* or *Q. phellos* (Laurel O. or Willow O.).

Nettle F. (*Urticaceae*): A large family of both woody plants and herbs. Common woody plants are *Ulmus* (Elm), *Celtis* (Hackberry) and *Morus* (Mulberry). Preparations as in the preceding, except that the fleshy fruits of *Morus* will have to be put in formalin. Common herbaceous plants are *Cannabis* (Hemp), *Humulus* (Hop), and *Urtica* (Nettle), the two former of considerable economic importance. Of the nettles *U. dioica* (Stinging Nettle) is perhaps the most important, an introduced weed of roadsides and waste places. Leafy branches with flowers and fruit can be shown, the plants being much too large to be shown entire.

Buckwheat F. (*Polygonaceae*): Species of *Rumex* (Sorrel) and *Polygonum* (Knotweed) are common introduced or native weeds. The economic *Fagopyrum esculentum* (Buckwheat) belongs here, likewise *Rheum Rhaponticum* (Garden Rhubarb).

Goosefoot F. (*Chenopodiaceae*): *Kochia* is well known in cultivation; it is one of the tumbleweeds, turning brilliant red in autumn. *Chenopodium* (Pigweed) has some introduced and native forms. The economic *Beta vulgaris* (Beet) and *Spinacia oleracea* (Spinach) belong here.

Amaranth F. (*Amaranthaceae*): Species of *Amaranthus* are common weeds, a few native. Celosia (Cockscomb) is common in cultivation. It shows the phenomenon of fasciation remarkably well, being habitually in this condition. *Iresine* and *Telanthera* are small foliage plants, used for bedding, and readily grown in terraria or the greenhouse.

Pink F. (*Caryophyllaceae*): *Stellaria* and *Cerastium* (Chickweeds) are common weeds about dwellings. *Agrostemma* (Corn Cockle) is a more or less common weed in grain fields, and along railroads. *Silene* (Catchfly) contains some viscid-glandular species, both native and foreign. *Saponaria* (Bouncing Bet) is now a common weed, escaped from old-fashioned gardens. *Dianthus* (Pink) contains a number of cultivated species, none native to the U. S. Some of the flowers are borne in clusters, as in

the Sweet William, while others are solitary. *D. caryophyllus* (Carnation) is one of the best known of greenhouse plants.

Water Lily F. (*Nymphaeaceae*): *Nymphaea* (Spatterdock), *Castalia* (Water Lily), and *Brasenia* (Water Shield) are genera more or less common in ponds and slow streams; all have floating leaves. *Nelumbo* (Lotus) with very large flowers and leaves, all raised high above the water, has one species native to the U. S., and a foreign species is common in cultivation. *Cabomba* (Fish Grass) is native in the southern U. S., and is the commonest aquarium plant, sold by all dealers in aquatics; it has mainly submerged dissected leaves, and small white flowers.

Crowfoot F. (*Ranunculaceae*): Species of *Ranunculus* (Buttercup), *Thalictrum* (Meadow Rue), *Hepatica* (Liverleaf), *Anemone*, *Clematis*, *Caltha* (Marsh Marigold), and *Aquilegia* (Columbine) are common native plants, some of them extensively in cultivation. *Ranunculus aquatilis* (White Water Crowfoot) is a good aquarium plant. Small plants of this family are easily kept in aquaria.

Poppy F. (*Papaveraceae*): *Papaver* (Poppy) is not native to the U. S., but one species is a very common garden plant, while a few others have escaped from cultivation. *P. somniferum* (Opium Poppy) is the species of greatest economic importance; it has escaped near dwellings in some places. *Eschscholzia* (California Poppy) is a very common garden plant. *Sanguinaria* (Bloodroot) is a common early spring flower.

Mustard F. (*Cruciferae*): *Draba*, *Radicula* (Water Cress), *Dentaria*, *Cardamine*, and *Arabis* are common native species. *Lepidium* (Peppergrass) and *Capsella* (Shepherd's Purse) are among the commonest weeds. *Lobularia* (Sweet Alyssum), *Lunaria* (Honesty), *Mathiola* (Stocks), and *Iberis* (Candytuft) are frequent garden flowers, while *Raphanus* (Radish), *Brassica* (Mustard, Cabbage, etc.), and *Armoracia* (Horse Radish) are economic plants.

Pitcher Plant F. (*Sarraceniaceae*): Species of *Sarracenia* (Pitcher Plant) and *Darlingtonia californica* (California Pitcher Plant) are readily kept in the bog terrarium. In this family the flower is remarkable for its large umbrella-like stigma. Flowers and leaves are best shown in formalin.

Sundew F. (*Droseraceae*): *Drosera* (Sundew) and *Dionaea* (Venus Fly Trap) are interesting insectivorous plants, best shown in formalin. They will live very well in the bog terrarium.

Orpine F. (*Crassulaceae*): *Crassula* (Orpine), *Sedum* (Stonecrop), *Sempervivum* (Houseleek), *Echeveria* (Hen-and-Chickens), and *Bryophyllum* (Life Plant) contain succulent species easily kept in dry terraria, with the exception of *Bryophyllum*, which requires a moist atmosphere; this is the classic plant for showing reproduction from leaves.

Rose F. (*Rosaceae*): This family contains a large number of native and garden forms, including *Rosa* (Rose), *Potentilla* (Cinquefoil), *Fragaria* (Strawberry), *Rubus* (Bramble), *Spiraea*, *Prunus* (Plums, etc.), *Crataegus* (Hawthorn), *Amelanchier* (Shadbush), *Sorbus* (Mountain Ash), and *Pyrus* (Apple, etc.), all woody plants with the exception of most species of *Potentilla*. Wild species of *Fragaria* and the related *Duchesnea* (Indian Strawberry) may be recommended for terraria.

Legume F. (*Leguminosae*): Common genera of this very large family are *Mimosa* (Sensitive Plant), *Gleditsia* (Honey Locust), *Cassia* (Senna), *Lupinus* (Lupine), *Trifolium* (Clover), *Melilotus* (Sweet Clover), *Medicago* (Alfalfa), *Amorpha* (Lead Plant), *Petalostemum* (Prairie Clover), *Robinia* (Locust), *Desmodium* (Tick Trefoil), *Lespedeza* (Bush Clover), *Apios* (Groundnut), *Dolichos* (Hyacinth Bean), *Pisum* (Garden Pea), *Arachis* (Peanut), *Phaseolus* (Bean), and *Glycine* (Soybean). *Mimosa pudica* is interesting to show motile leaves; it is readily kept in the greenhouse or Wardian Case. Seeds can be had from dealers. Small species of *Trifolium* can be grown in terraria.

Wood Sorrel F. (*Oxalidaceae*): Species of *Oxalis* can be found about dwellings as common weeds. Another species is a handsome spring flower. *O. rubra* is a very common house plant.

Geranium F. (*Geraniaceae*): *Geranium* has several species both wild and as introduced weeds; a few are planted in the garden. The house geraniums belong to the genus *Pelargonium*, of which a selection would include *P. peltatum* (Ivy Geranium), *P. hortorum* (Fish Geranium), the commonest cultivated species, including the foliage plants known as Silver-leaf Geraniums, *P. domesticum* (Lady Washington Geranium), and *P. graveolens* (Rose Geranium) with finely cut sweet scented foliage. All the house plants will do well in the greenhouse or perhaps in the school room.

Spurge F. (*Euphorbiaceae*): *Ricinus* (Castor Oil Plant) is a common medicinal and decorative herb. *Euphorbia* contains both wild and cultivated species. *E. maculata* (Milk Purslane)

is a common weed in most places, while *E. pulcherrima* (Poinsettia) is frequent as a pot plant.

Maple F. (*Aceraceae*): Species of *Acer* (Maple) will be found both wild and cultivated. An interesting preparation can be made of the leaves and fruits of several species, including *A. Negundo* (Box Elder), *A. saccharum* (Sugar Maple), *A. rubrum* (Red M.), *A. saccharinum* (Silver M.), all native species, and *A. platanoides* (Norway M.), often cultivated.

Mallow F. (*Malvaceae*): *Abutilon Theophrasti* (Velvet Leaf) is a very common weed, especially in the central states, *Althaea rosea* (Hollyhock) is abundant in cultivation, *Malva rotundifolia* (Cheeses) is found along roadsides, etc., *Hibiscus* in many species is found both wild and cultivated, while *Gossypium* (Cotton) can be had in the southern states.

Violet F. (*Violaceae*): *Hybanthus* (Green Violet) is found in rich woods. Several species of *Viola* are to be recommended, especially *V. pedata* (Bird's Foot Violet), which has only the showy flowers, *V. cucullata* (Common Blue V.), with both showy and cleistogamous flowers, *V. pubescens* (Downy Yellow V.) or *V. conspersa*, which also have cleistogamous flowers, but unlike the preceding have leafy stems, and *C. arvensis* or *V. Rafinesquii* (Wild Pansies), very small pansy-like violets, the first naturalized in old fields, etc., the second a native in woods or open places.

Begonia F. (*Begoniaceae*): No species of the genus *Begonia* is native to the U. S., but many are cultivated as house and conservatory plants. To be recommended are *B. semperflorens* (Everblooming Begonia), *B. Rex-cultorum* (Rex B.), and *B. tuberhybrida* (Tuberous B.). *B. semperflorens* blooms almost continually, and is excellent to show the two kinds of flowers, staminate and pistillate.

Cactus F. (*Cactaceae*): *Opuntia* (Prickly Pear) has one species in the Atlantic States and one in the middle west, while many occur in the southwest. *Pereskia* of tropical America is interesting in having large pale green leaves, which function to some extent, unlike all other cacti. *Cephalocereus* (Old Man Cactus) has long white bristles. *Hylocereus* (Night Blooming Cereus) is common in cultivation. *Aporocactus* (Rattail Cactus) has unusually slender stems. *Echinocereus* and *Mammillaria* are globose forms of the southwest. *Zygocactus* (Christmas Cactus) is one of the commonest house plants. All are fleshy forms, and

can be grown in the desert terrarium, school room, or greenhouse.

Evening Primrose F. (*Onagraceae*): *Jussiaea* (Primrose Willow) is found in shallow water in the southern states, and is readily cultivated under like conditions. *Ludvigia* (Water Purslane), common in ditches, etc., is one of the best of aquarium plants. *Epilobium* (Fireweed) has tufted seeds as in the milkweeds, enabling it to occupy at once burned over areas. Species of *Oenothera* (Evening Primrose) are common native plants, while *O. biennis* is one of the commonest weeds. *Trapa* (Water Chestnut) is an interesting aquatic with both submerged and floating leaves, the latter with inflated petioles serving as air bladders, and spiny fruit. It has become naturalized in some parts of the eastern U. S., and can be bought of some dealers in aquatics. *Fuchsia* is a well known house plant.

Parsley F. (*Umbelliferae*): Common native plants are *Eryngium* (Rattlesnake Master) with spiny leaves and dense flower heads, *Hydrocotyle* (Water Pennywort), a creeping plant of wet places, good in the bog or swamp terrarium, *Osmorhiza* (Sweet Cicely), and *Thaspium* (Meadow Parsnip). *Pastinaca sativa* (Parsnip) is a very common weed, as well as a favorite garden vegetable. Some aromatic herbs belong here, as *Carum* (Caraway) and *Coriandrum* (Coriander), while *Apium* (Celery) is everywhere known.

Dogwood F. (*Cornaceae*): *Cornus* (Dogwood) contains several species, among them being the herbaceous *C. canadensis* (Bunchberry), and the shrubby *C. stolonifera* (Red-Osier Dogwood) and *C. florida* (Flowering D.). *C. canadensis* may be tried in the woodland terrarium. *Nyssa* (Black or Sour Gum) is a common tree on the edges of swamps, the leaves turning a brilliant red in autumn.

SHIP TO DRIFT YEARS IN ARCTIC

An extra-strong wooden ship, whose ultimate duty will be to become frozen in Arctic ice and drift with the ice fields into high latitudes, will be completed early in 1937, Prof. Wiese, Soviet explorer has announced here.

In general the design of the ship will follow that of the "Fram" used for similar duty by the Nansen expedition to the Arctic in 1893–96.

The chief object of the expedition which will use the new ship will be a thorough study of the deep parts of the Arctic basin which are covered the year round with an ice crust so thick that the strongest ice breakers cannot pierce it.

SEVENTY-FIVE YEARS OF SCIENCE

By H. R. Fisher

Sunbury High School, Sunbury, Ohio

In the first part the instructor and the pupils are to dress according to the styles of 1860. The stage is to be set to represent a schoolroom of 1860. In the second part all are to wear modern dress and the stage is to represent a modern schoolroom.

PART I

(*The class files into the room and the instructor takes his place at the desk.*)

Instructor—The class in Natural Philosophy will now come to order. As was announced yesterday, we will review some of the outstanding achievements in the field of science on this our last day of the school term. I hope that each of you has for us an interesting as well as instructive report on the subject assigned to you.

We are proud of our development along lines involving the application of science to everyday living and when we review the whole field, at once the question which presents itself to us is, "What more can be invented?" It would seem that we are about at the end and that it is impossible that the next seventy-five years can produce the wonderful development in scientific things and the number of inventions involving scientific knowledge that the past seventy-five years have. But let us not be too pessimistic. The achievements of the past are enough for us to be proud of. So we meet today mentally to travel back over these years of accomplishment and maybe speculate the least bit on what the future holds in store for us.

We will now lend our attention to the reports which you have prepared on the special subjects assigned to you. Ethan Allen Brown will talk first on the subject, "Lighting with Electricity."

Ethan Allen Brown—As we all know, the word electricity originated with the Greeks who noticed that when amber was rubbed it would pick up light objects such as thread, hair, paper and various other like materials. So we have borrowed the Greek work "Elektron" which meant "amber" and from it coined the word "electricity."

What electricity is nobody knows and as yet there seems to be no real practical use for it. Certainly not enough can be generated by rubbing amber to do any real work and the

method employed by Mr. Franklin of drawing it out of the clouds is far too dangerous. It is true, an Italian named Volta succeeded about sixty years ago in producing current from a battery but the weight and the cost of the battery prohibits its general use. So it would appear that this thing called electricity is forever to remain only a dangerous plaything for scientific people.

As far as being used for lights, it seems that such an idea is only a pipe dream and the result of the wanderings of an unbalanced mind. Of course there have been attempts made to use it but none have been very successful.

About fifty years ago Sir Humphry Davy of England noticed that a light could be produced by touching together two carbon rods carrying current and then separating them the least bit. He called this an electric arc, but so far it is only a scientific curiosity. He also noticed that by sending a current through a fine platinum wire he could make the wire red hot, but, of course, we all know that if the wire should get hot enough to produce light it would burn up. Anyway it would cost too much for the current since Mr. Davy had to use a battery of 2,000 cells to produce even this effect. So my conclusion would be that this idea of producing light with electricity is one which will never pass the experimental stage and never cease to be anything but a mere scientific plaything.

INSTRUCTOR—That is fine, Ethan, and I believe you are correct in saying that the idea of using electricity for lights will never get out of the experimental stage. I believe you forgot to mention that a man by the name of Starr attempted about 14 years ago to make a light with a glowing wire in a bulb of glass but was not successful.

We will now listen to Adam Price tell us something about the use of the electric current as a source of power.

ADAM PRICE—About twenty-nine years ago Professor Joseph Henry who was then teaching in Albany Academy at Albany, N. Y., invented the electromagnet and at about the same time Mr. Michael Faraday of England noticed the same peculiar magnetic effect of a wire carrying an electric current. He suggested using it for power and so invented a sort of device which he called a motor. It was nothing more than a solid disc free to revolve on its axis. It was placed between the poles of a horseshoe magnet and current sent from the axis to the edge of the disc. This made it revolve but it had no great pulling power. The current used, of course, came from a battery.

Various attempts were made to improve this disc motor, among them the substitution of electromagnets for the permanent magnets, and the use of a bunch of coils on the axle instead of the disc. Some really powerful motors have been made, and for but one thing it seems to me, the electric motor might be a commercial success. It costs too much for the battery to supply the current and the battery would be too heavy to be moved around much.

Mr. Thomas Davenport, a blacksmith of Brandon, Vermont, made an electric car about twenty-five years ago but the thing did not run well enough to be called a success. Then about twenty-two years ago a man by the name of Robert Davidson of Aberdeen, Scotland, made a car for a standard gauge railroad. This was more successful and made a few trips.

Ten years ago Professor C. I. Page of Washington, D.C., thrilled the world with a new kind of railroad locomotive. It was an electric and was tried out on the Baltimore and Ohio railroad running into the city. The motor developed 16 horsepower and on its trial run made a speed of 19 miles per hour. Truly it would seem we are about to enter a new electrical age but on second thought we are brought face to face with the hard facts that these electrical machines are not practical. They must depend on huge batteries for their source of power which makes them cost more to operate than steam engines and then engineers have found that there seems to be a backward current generated in the rotating coils which hinders the flow of current from the battery. Until these difficulties are overcome it seems that the age of electrical power is as far off as it was one hundred years ago.

INSTRUCTOR—The next topic for discussion is "Electric Storage Batteries." Josiah Warner will enlighten us on this most interesting although, I must admit, little known subject.

JOSIAH WARNER—Almost exactly fifty-nine years ago a Frenchman named Gautherot found that platinum wires used in the electrolysis of salt water would produce an electric current in a reversed direction after the electrolysis process had been running for some time. He concluded that either electricity or some peculiar effect of the electricity had been stored in the salt solution or on the wires, and that this caused the backward current when the battery was disconnected. He suggested this as a possible method of storing electricity.

Two years later Ritter made a sort of a battery of copper discs and cloth soaked in sal ammoniac and then about nineteen years ago Grove made a battery using hydrogen and oxygen as the plates in which to store electricity. This battery, however, was for experimental purposes only.

This recital of the attempts to make a device for storing electricity seems insignificant when compared with the long list of defects of such devices and the reasons why they are not practical.

In the first place they are too delicate to stand hard usage; they are too heavy to be moved from place to place if made in large enough units to produce any great amount of current; they cost too much to construct; they are easily ruined by mechanical abuse and jars and, finally, if they could be made, there is no means of generating current in large enough quantities to charge them if they were of a size to do any work.

Their delicate nature alone would prevent their use anywhere but in a laboratory where they may receive the best of care and then again the small amount of current that may be drawn from them in proportion to the amount put in sends the cost of operating them too high, which, coupled with their unreliability puts them in a class of things which are interesting to play with and look at but are of no practical value.

INSTRUCTOR—Then you would say the storage battery seems to have no future?

JOSIAH WARNER—It seems so to me. It certainly could never be made to furnish current for electric locomotives because of its inability to stand shocks. It would be shaken to pieces or smashed to bits before the train had gone a mile. And then to get enough power it would be necessary to use a battery which would occupy a whole car or more. Finally where would we get enough electricity to charge it?

INSTRUCTOR—That is fine, Josiah, and I believe you are right in your statement concerning the use of the storage battery and its future possibilities.

We now pass from the discussion of things of an electrical nature to a consideration of a few of our rare metals. Those unusual metals which we know so little about and which are so interesting because they are so uncommon. Although they have no commercial value, they are priceless because of their scarcity and so occupy a place on museum shelves and in laboratory displays along with gold, diamonds, platinum, etc.

We choose a metal of this class when we discuss aluminum. Penelope Baxter will favor us at this time with a discourse on the metal aluminum.

PENELOPE BAXTER—When one mentions the words "rare metal" our minds instantly bring up the names "gold and silver," probably because they are common names. We recognize the metals when we see them and we all know they are our standards of money—hence they are valuable because they are fairly rare.

However, say "aluminum" and we are not quite so quick to form a mental picture. Aluminum, you repeat to yourself and then after a mental game of tag some half-forgotten memory comes glimmering through the haze and you remember the very light, shiny, white metal which you saw on display in a museum, and it must be a good museum for not all of them can afford enough of this peculiar metal to make a decent display. You remember the sign saying there was no use for this metallic curiosity and if there were, it would be entirely too costly since the present price is about $90 per pound.

Historically, it is practically a new metal. Sir Humphry Davy recognized it first as a new element which had never been described before. Then about thirty years ago it was separated in the pure form for the first time. No improvement was made in the method of producing it until about six years ago, although it has been known for some time that it is present in practically all kinds of clay.

Six years ago a Frenchman by the name of Deville produced some of the metal by the use of the electric current, and so startling were his results that the attention of Napoleon III was drawn to his experiments. The result was that Napoleon aided him in building a factory at Javelle, France, but the lack of sufficient electric power prevented any great success.

The visitors at the World's Fair in Paris five years ago were thrilled beyond description by the exhibit of aluminum. Small bars of the metal were on display and attracted the attention of thousands.

Sober second thought, though, emphasizes the absurdity of expecting too much from this metal. The price is too high. Nobody will be foolish enough to make a cup, let us say, from a metal costing $90 a pound when one just as good can be made from iron at a few cents a pound.

INSTRUCTOR—You believe then the price alone of this new

metal will prevent it being widely used? Does your investigation show any other factors which might prevent its widespread use?

PENELOPE BAXTER—Yes. It is rather brittle and doesn't seem to be able to stand much hard abuse such as steel will stand. Of course, its lightness would make it desirable for carriage and wagon parts and it might be used in machinery where the strain is not too great. But I am sure unless a new way of making it is found it will never be anything but a metal for show and display.

INSTRUCTOR—Very fine. And now pupils we will listen to a report on India gum or rubber as it is now being called, by Abigail Smith.

ABIGAIL SMITH—India gum or caoutchouc, to use the proper name, was first discovered by white men when Columbus made his second voyage to America. He noticed that the natives were amusing themselves by bouncing and throwing about balls made of a peculiar brown, spongy substance which was made from the sap of a certain tree. To him it was but another one of the curiosities of the voyage.

It was not until 1736 that the stuff was first studied and in that year samples of it were presented to the French Academy of Sciences. The name given it was elastic gum. In 1770 or about ninety years ago, Joseph Priestley of England suggested that it be called "rubber" because it was valuable for rubbing out pencil marks. This was the only use for it as far as we know.

About sixty years ago some of this new material was brought to America for the first time. It had no commercial value except as a curiosity. Not until about forty years ago was it discovered that it could be made into tubes and bottles for the use of chemists and surgeons.

Then in 1823 a Scot by the name McIntosh made a wonderful contribution to the comfort and well-being of humanity by putting a layer of rubber between two layers of cloth and sticking them together. This made a water-proof garment and McIntosh has had wonderful success with his new discovery. About eight years ago a Boston sea captain cause a sensation when he brought into this country 500 pairs of boots made of rubber by the Brazilian natives. He sold the boots for from $3 to $5 a pair and soon rubber boots were all the style. They are a godsend when compared to the old leather boots which easily become water soaked in wet weather unless well greased. Let us all hope that the rubber boot business may grow and prosper.

Attempts were made to make various articles of rubber but always there was the trouble that they would melt and get sticky in hot weather and harden and crack in cold.

Some twenty-four years ago a German chemist found that a little sulphur added to the gum would remove the stickiness. An American named Charles Goodyear bought his patent rights and continued to experiment with rubber. One day he accidentally dropped a piece of the gum with sulphur mixed with it on a hot stove and was surprised to find that it did not melt and get sticky. He also found that cold would not harden it. This was the very thing which he had been working for. To carry the idea that heat had something to do with the preparation of the the new rubber he called the process "vulcanizing" in honor of Vulcan the god of fire.

All of this happened just sixteen years ago and already rubber is one of the principal staples of everyday life. Boots and overshoes keep us out of the mud; rubber garments keep the rain off; rubber bands hold our letters and documents together and it is said there is a buggy factory somewhere that is advertising buggies with rubber ties. They claim they ride easier and make less noise on pavements than the regular steel tires. Let us hope that some day it gets cheap enough that all of us can have rubber tires on our buggies.

INSTRUCTOR—Very good Abigail, very good. I too hope the day will come when we can all enjoy the luxury of rubber tires on our carriages.

And now pupils I think we have all enjoyed a very profitable class session as well as a very interesting one. I hope we may again meet for just such a review of science at a later date. May you enjoy a very pleasant vacation and return next term for more of the fascinating work in the field of science or natural philosophy. The class is dismissed.

(*The class files out followed by the teacher.*)

PART II

(*The students and instructor file into the room and take their places as in a modern schoolroom.*)

INSTRUCTOR—As we announced yesterday we meet today to review some of the outstanding achievements in science during the past seventy-five years. It would take days and even weeks to completely review all the accomplishments of science for

that period, so we will confine our discussion to but a few of the most remarkable ones.

We make no prediction for the future but at the same time we recognize that the goal has by no means been reached. We are not yet at the top but what is ahead is not for us to predict. We can only speculate by contemplating the accomplishments of the past.

Our first discussion will be on "Lighting With Electricity" and will be given by Rollin Comstock.

ROLLIN COMSTOCK—Without doubt the most remarkable and the most noteworthy experiment of the past century was the one conducted at Menlo Park, New Jersey, on October 21, 1879. It compares favorably with Pasteur's experiment with anti-rabies serum; with the experiment on soldiers of the American army to find out the cause of malaria and yellow fever, and with the development of the radio. I refer to the experiment of Mr. Edison when he lighted the first successful incandescent lamp. Unfortunately for our friends in the museums, the first lamp is not in existence. After it burned out Mr. Edison tore it down to find out its weaknesses. He was after a successful lamp and not fame.

From that crude bulb with its frail filament made of carbon it seems a far cry to the modern flood lamp we see so often on airplane landing fields—lamps which would dim even 10,000 of the original lamps of Mr. Edison's first venture. From a filament made of carbonized split bamboo, we have progressively advanced through the stages of the "squirted thread" filament, the metallized filament and the tantalum filament and have at last arrived at the modern coiled tungsten filaments capable of producing about 5 times the light from the same current that Mr. Edison's first lamp produced.

We have passed from the old reddish yellow carbon light to the powerful, gas-filled daylight effect lamp. However it wasn't until Mr. Brush of Cleveland and Mr. Edison had developed a mechanical means of generating current that the real development of the electric light was possible. Batteries are too costly and cumbersome for a very large installation.

Today we have the individual small generator in the farm light plant; each automobile has its own power plant; trains carry generators belted to the car axles and the locomotive has its own steam-driven generator; immense generators at central

power stations develop thousands of horsepower to be sent throughout the country for light and power.

Ultra-violet lights restore us to health and give us a sun tan when the sun isn't even shining. Mercury vapor arc lights imitate the sun in furnishing light for photography. Immense searchlights pick out distant objects and floodlights allow us to play football at night.

It is said the largest lamp made is one used to illuminate aviation fields. One bulb alone requires 50,000 watts or the equivalent of about 67 horsepower to operate it. The smallest bulb is known as the "grain of wheat bulb." It is about the size of a grain of wheat and is used by surgeons on a periscope-like device with which they explore the inside of the stomach. Bulbs of all shapes and descriptions are in common use and electricity is almost as common for lights as kerosene was fifty years ago. Thus in seventy-five years we have succeeded in bringing light into darkness and have almost equalled the sun in brilliancy. What the next seventy-five years will produce is a question.

INSTRUCTOR—Very well done. You are wise in not predicting the future as we are living in a rapid age. What is correct today may be antiquated tomorrow. We must progress or decay.

We will next listen to a report on "Electricity as a Source of Power" by Jane Perfect.

JANE PERFECT—A long pullman train is slowly pulling into the terminal in New York City. It is far underground. You put your nose into the air and sniff for the smell of coal smoke. It isn't there. You keep blinking in anticipation of cinders in your eye but they are not there. You investigate and find that the engine pulling the train is not a puffing, smoke-belching monster, but a quiet, neat looking sort of car. There is no coal or oil tender attached; there is no fireman, in fact there is no fire. A cable stretched overhead seems to be furnishing all the power to a clean, compact, well encased piece of machinery inside. The movement of a lever by the engineer seems to be the "open sesame" to a flood of power. Power with no jerks or blasting exhaust. Only a steady humming. You are aboard an electric locomotive!

The thing called an electric motor was almost unknown three quarters of a century ago. There were some in use but they were very small since they had to depend on batteries for their source of power. Thanks to Mr. Brush and Mr. Edison we now have

mechanical generation of electricity. Whereas batteries would generate power to run motors of 10 horsepower, we now generate it at the rate of thousands of horsepower. One of the most noteworthy applications of electric power is to railways.

In 1883, Mr. Edison and Mr. Field exhibited an electric locomotive in Chicago and the next year the first overhead trolley system in America was installed in Kansas City. Since then there has been a rapid development both in trolley systems and electric railways. By 1920 the Chicago, Milwaukee and St. Paul railway had about 660 miles of its tracks in the mountains electrified. They found that electric locomotives could pull 50% more load than steam engines and at a greater speed.

Electric locomotives pull trains into practically every large terminal in the country and in European countries, notably Switzerland, Norway and Sweden, electric power is replacing steam because of the scarcity of coal and the abundance of water power for generating current.

We are living in an electrical age. The age of steam for small power is slowly passing. Electric motors crank our Fords; they keep us cool when attached to a fan and they drive the drill with which the dentist entertains us. They run our mills and hoist our ores from deep within the earth; they circulate the warm air in our houses and keep our food cool in the iceless refrigerator. They are compact, clean and neat looking. They are powerful for their size and more efficient than the steam engine. They know nothing of the terrors of hot or cold weather. They never get tired and if cared for properly will run indefinitely. The electric motor is our friend and is just finding its place in our scheme of living. Electricity is removing some of the drudgery from life. Great progress has been made in the past century along this line and it is my prediction that we have just scratched the surface in our attempts to put man's greatest and most willing servant, electricity, to work.

INSTRUCTOR—Most excellent, I must say. You too seem to realize that our greatest progress is not in the past but is yet to come. And now Elliott Wilson will tell us something of the development and use of "Storage Batteries."

ELLIOTT WILSON—Little did the early investigators who noticed the peculiar storage effect of the electric current in certain materials dream that the thing called a storage battery would be so common and essential today. They condemned the storage cell as being too delicate and unreliable for ordinary

use. They said storage batteries would never be more than interesting playthings for use in laboratories only. And it is true that the batteries as they knew them were not fit for very hard usage. Since that time there has been a wonderful development in storage cells.

Generally there are but two types of cells to be considered. The first is the ordinary lead plate cell with which we are so familiar and the second is the Edison nickel-iron cell which is not so familiar.

The lead plate cell is a sort of evolved cell which was invented by no one person in particular but was developed by many investigators. The Edison cell, which is very much different, was, on the other hand, invented by Mr. Edison. It is very much lighter and will stand more abuse but it doesn't deliver quite as much power as the other type.

Storage batteries play an important part in our life today. First of all for starting, lighting and running our autos and also to operate our radios. Both large and small storage batteries act as A and B batteries for radio work on the sending as well as the receiving end. The voltage that may be produced is unlimited.

Probably the largest storage batteries in use are those on submarines. These ships, of necessity, must use electric motors for power when submerged. Storage cells that stand as high as a man furnish current for the motors.

In some power stations storage batteries stand by ready to supply current in case of a breakdown in the generating machinery or as a booster at times of peak load.

Storage batteries operate our automatic train signal systems; they operate warning signals and they light our trains. They are the means by which we literally carry power into places where it otherwise could not go and also by which we can store power for future use. Surely we would be tremendously handicapped without our old friend the storage battery.

INSTRUCTOR—There is no question that the development of the storage battery has been one of the outstanding achievements of the last three quarters of a century. It is a necessity if we are to keep pace in other electrical lines.

Eleanor Condit will now take us from the field of physics and bring us into that of chemistry by a discussion of "Aluminum."

ELEANOR CONDIT—If the question, "what is the most abundant metal on earth" were asked the answer would correctly be

"Aluminum," although few of us realize it. Every bank of clay has quantities of aluminum in it; your farms are veritable mines of this metal. This is no new discovery although the development of a process to remove it is fairly recent.

Seventy-five years ago aluminum was a rare curiosity with a market price of about $90 a pound. Today it sells for 12 cents a pound. Then it was exhibited as a rare metal; today it is probably next to iron in its usefulness.

We owe our thanks for all this to Mr. Charles M. Hall of Oberlin, Ohio. While a student in Oberlin College in the early eighties he became interested in the development of a method of extracting aluminum from its ores. Patient experiment, some of it carried on in his father's woodshed, resulted in the modern method of extracting the metal by the electric current. Immediately the price of aluminum went down and as the price decreased the uses of the new metal increased.

Aluminum cups, plates, wire and kettles are too common to call for much discussion. Daily, almost, we are discovering new uses for this wonderfully light metal. Slowly it is taking the place of other metals where lightness and strength must be combined.

It is about as strong as cast iron; can be rolled almost as thin as gold and conducts electricity about 55% as well as copper. Its biggest use, however, is not in the pure form but alloyed with other metals. One of the outstandingly useful alloys of aluminum is called duralumin. It is composed of aluminum, copper, manganese and magnesium.

If you had visited the hangar of the Goodyear-Zeppelin Co. at Akron you would have seen most likely one of the large dirigibles in process of construction. If you were allowed a very close view you would have seen that the framework of this giant of the skies was made of a peculiar white metal, almost as hard as steel and incredibly light. A girder about the size and appearance of an ordinary bridge girder would not be a respectable sized load for a man. The metal used is duralumin which was first made in Germany just before the World War. This metal made possible the all metal airplane and the airplane engine of enormous horsepower but little weight.

Various other alloys of aluminum do duty as engine parts, pistons, bodies and body hardware. We make protective paints out of the pure metal and there is even aluminum furniture on the market now. It may be that your future home will be fur-

nished with aluminum chairs, tables and desks, your walls painted with aluminum paint, your kitchen utensils made of aluminum, the various electric motors used about the house wound with aluminum wire and the line bringing in current made of aluminum.

These are a few of the uses of this remarkable metal. We have no time to describe its use in the chemical laboratory or in other industrial processes—how by the aid of aluminum it is possible to weld enormous castings without removing them, weld car rails and repair breaks in even the rudder posts and propellers of giant steamships without even removing them. The world is demanding speed and more speed and this strong though light metal will help us get this speed.

INSTRUCTOR—I am sure, Eleanor you almost convince me that aluminum and its alloys are about the only existing metals that amount to anything. Probably we are becoming more aluminum conscious every day. Its low price and of course widespread use in the future will all depend on our ability to produce cheap electric power.

And now last but not least we will listen to a discussion of the uses of rubber by Neal Hervey.

NEAL HERVEY—It is likely that Charles Goodyear had little idea of what he was starting when he accidentally dropped a mixture of rubber and sulfur on a hot stove on that day in 1832 and thereby discovered the secret of vulcanizing. The results were remarkable, first, in that it produced the desired change in the rubber and second, it started a long line of investigation and development of rubber until we are literally riding on rubber these days.

From depending for our supply on the wild rubber from the forests of Brazil we have progressed to the place where immense plantations of rubber trees supply our demand and as a result of Mr. Edison's investigations we may some day be harvesting the lowly goldenrod and maybe other weeds for the rubber found in their juices.

From the old crude gum dried over a smoky flame, we have progressed to the gum dried by being sprayed from a centrifugal machine into a very hot, dry room where the gum is produced as a fine white powder of almost 100% purity.

We have learned how to mix various materials with rubber to produce rubber of all degrees of hardness, color and elasticity.

Substitutes have been developed which even excel rubber for certain uses.

The auto business has been the greatest stimulant to the production of rubber. Tires are made bigger and better every day. Rubber mats cover the floor of your machine, rubber blocks absorb the vibration of the motor, rubber spring shackles take up vibration and incidentally cheat the grease man out of a job, rubber blocks replace slow bearings, rubber hose connects the radiator to the engine, rubber insulates the spark plug wires and in some cities even rubber pavement reduces the wear and tear and at the same time soothes our nerves by decreasing street noises. This seems a far cry from the time when we hoped that all of us might afford rubber tires on our buggies.

Rubber shoes, clothing, gloves and hats are all very common. Rubber mats keep you from breaking your neck in the bath tub and rubber sponges have driven the common sponge from the bathroom. Rubber makes your water hose leak proof and might add to the properties of the hose as a disciplinary agent.

Because rubber is not affected much by acids and chemicals it is used by chemists in the form of tubing and stoppers and by the storage battery manufacturer for insulators and battery cases.

I might go on ad infinitum listing the uses of rubber but it is sufficient to say that their number is legion and the end is not yet in sight.

INSTRUCTOR—This concludes our discussions and to all of you I might repeat what the last speaker has just said, "The end is not yet in sight." The future holds promise of more improvement than the past has witnessed.

FISH MAY BE USED TO DETECT FLUORINE IN DRINKING WATER

Small fish may in future be used to detect the presence of fluorine in drinking water instead of the tedious chemical tests now necessary, it appears from a report by Dr. Andrew Neff of the California Institute of Technology.

Small amounts of fluorine in drinking water cause a condition known as mottled enamel in the teeth of children who drink such water. Dr. Neff now finds that the teeth of fish living in fluorine-containing water also are affected. If the degree to which the fish teeth are affected can be accurately correlated with the amount of fluorine in the water, the fish test may replace the lengthy chemical analyses now used to detect the very small amounts of fluorine which cause the condition.

GRADE PLACEMENT IN ELEMENTARY SCHOOL SCIENCE

By G. W. Haupt

State Teachers College, Westfield, Massachusetts

Elementary school teachers, supervisors, and curriculum workers are greatly interested in the grade placement of science and nature study materials. This seems to be a matter of paramount importance at the present time. At a recent meeting of the National Council of Supervisors of Elementary Science the need of grade placement investigations was stressed (1). It may be helpful therefore to present a review of the methods which are used in grade placement of science and nature study materials along with a discussion of some data which have recently been secured from an experimental study of children's graded learning in elementary school science.

THREE PROCEDURES IN GRADE PLACEMENT

There are three proposals before the field which are followed in practice. They are: (A) vary the aim of instruction on different grade levels; (B) treat different sciences on lower and higher grade levels; and (C) integrate content from all of the sciences by means of an objective and grade the contributory content on the basis of its progressive complexity.

VARY THE AIM

Concerning the first method it is proposed, for example, that "in the lower grades the dominant purpose shall be the aesthetic; in the upper grades the dominant purpose shall be the economic and social" (2). Perhaps the fullest presentation of this basis for placement is found in the Fourth Yearbook of the Department of Superintendence (3) where the following aims are listed: (a) Ethical, (b) Spiritual, (c) Aesthetic, (d) Intellectual, (e) Social, (f) Civic, (g) Economic, (h) Vital, (i) Avocational, (j) Vocational, (k) Practical. Under each of these eleven aims there are listed a total of seventy subaims which range in apportionment from one subaim for aim number eleven to twenty-one subaims for aim number four. Examples of such subaims are: "Desire to follow the truth—moral uprightness" and "Ability to create beauty and to use it."

Although these proposals were written from eight to fifteen years ago they influence practice today as reference to courses

of study and attendance at curriculum meetings will show.

Such aims undoubtedly state outcomes of high value. Unfortunately, however, we have no objective studies in the field of science education which give data on the significance and implications of these aims for instruction or grade placement. As curriculum analysis has proceeded they have become confusing and impractical criteria. They are not definitely directive and because they are so broad and general it has been so far impossible to find standards by means of which their attainment may be measured. But it may be questioned whether research should not be made to determine functional implications of aims of this type. There are studies in the field of psychology which are suggestive. Only a few titles can be mentioned here (4).

BIOLOGY FOR THE LOWER GRADES

According to the second method content from biology is used almost exclusively on the lower levels; reserving that from the physical sciences for the higher levels. Three reasons or assumptions underlie this proposal. One is that children are more interested in biological materials; another is that biology is of greater social utility; and the third is that biological materials are simpler and easier than physical science materials.

Numerous studies of children's interests have been made (5). The findings and conclusions are somewhat conflicting but on the whole there seems to be some advantage shown in favor of biological interests in the lower grade levels. To what extent these predominant biological interests are suggested and fixed by environment, in all of its aspects, has not been studied. Some of the data presented by the interest studies suggest that the predominant interests and training of elementary school teachers, parents, and writers for children are biological and that this is a strong factor in the determination of the children's interests. There is also the question as to whether the science of the early elementary grades should be almost exclusively biological even though the interests of the children might be of this nature. This question of the extent to which interests should determine the curriculum is prominent in all grades and subjects and at present we have little more than opinion as criteria.

Craig (6) made an evaluation of elementary school science curriculum materials in terms of social utility and there are studies, evaluations and syntheses, like those of Curtis (7) and

Harap (8) which are pertinent although they were not made directly and solely for use in the grades. None of the studies of this type support the assumption that content from the biological sciences is of greater social value to children than content from the physical sciences.

Concerning the third reason or assumption, the opinion is widespread that content from the physical sciences should not be presented to children because it is so much more difficult than that from the biological sciences. However there is also the counter opinion that one science need not necessarily be more difficult than another for children (9). We have an objective study bearing upon this question (10), and it may be worthwhile to indicate how unwarranted inferences and applications have been made by teachers and curriculum workers from the data of this study.

Webb concluded that physical science materials were not suitable for children of the lower grade levels *according to the tests and standards of his study*. It is this qualification which teachers do not consider when they evaluate the study.

Briefly, it may be said that the tests were devised to determine knowledge of topics and principles which was held by a particular group of children from sixty-two different schools throughout the United States when they had reached the last three grammar grades. The tests did not determine how much of the knowledge contributory to the topics and principles it might be possible for the children to learn. There was testing of what had been done under widely varying conditions but not of what could be done under controlled conditions. In other words, there was no experimental teaching preceding the testing.

Furthermore, the tests were framed from an analysis of logically organized topics or units taken from textbooks. There is quite a difference between a logically organized topic or unit and one organized from considerations of the manner in which progressively graded children would learn such topics or units (11). Tests constructed on the first basis might not reveal many elements of learning concerning the topics which the children knew. It is a significant fact, so often overlooked by teachers, that the conclusion is reached in this study that *Biology is not suitable until the seventh grade.*

GRADATION BY MEANS OF AN INTEGRATING OBJECTIVE

The principle of the third proposal for grade placement has been defined by Craig (12) and interpretations and applications

are to be found in several reports and studies (13). According to this method, the content is selected by means of an objective which is definitive of subject matter. Such contributory subject matter might be drawn from any or several science fields. The particular field of science is not considered of primary importance. Instead, attention is focused upon those materials from the various sciences which will contribute to an understanding of the objective. Placement is determined by the relative difficulty of the elements of a range of contributory content thus selected. Understanding of the objective is said to be progressive and cumulative from grade to grade; there are no shifts or breaks from aim to aim or from one science field to another.

Some implications of this method of gradation and placement have been recently studied (14). The integrating objective was "The Sun is the Source of Energy for the Earth." The study was narrowed to one aspect of energy transfer, namely, that found in the green plant. Thus the problem was one of presenting certain experiences, chiefly with plants, to elementary school children for the purpose of interpretation in terms of energy transfer.

A grade placement based upon objective data resulted but of more importance are any criteria which may have general application in curriculum work.

Examination of the following two sets of learning elements which are selected from the post instructional test data will reveal certain features:

SET I

Plants get green in the light and yellow in the dark
Green plants turn toward the light
Plants grow in the light
Plants need water, air, and light to live
The sun gives us heat

SET II

Fish breathe in oxygen and breathe out carbon dioxide
Green plants give out oxygen in the presence of light
There is an oxygen carbon dioxide cycle between the fish and the green plant in the presence of light
Green plants make food with the help of light
Green plants store up energy from the sun
Sunlight can be transformed to heat, light and power

It is apparent that there is a fundamental difference between the elements of the first set and those of the second set. The

elements of the first set are simpler than those of the second set. What factors determine this difference?

It will be noted that these elements are statements of association between concepts. For example, the element "Plants get green in the light and yellow in the dark" states a relationship between the concepts *green plant, yellow plant, light,* and *dark.* The element "Green plants make food with the help of light" states a relationship between *green plant, food making,* and *light.* To learn or teach that green plants get yellow in the dark is much simpler than to learn or teach that green plants make food with the help of light because children easily learn functional meanings of *green plant* and *yellow plant* and establishment of the involved relation between *green plant, yellow plant,* and *light* depends upon rather simple observation. But to learn or teach a functional meaning of *make food* is not nearly so easy and establishment of relation between *green plant, make food,* and *light* does not depend upon simple observation.

The difference between the elements of the first set and those of the second set is found in the relative complexity of the concepts and associations of these concepts.

These few examples illustrate the kind of grouping which emerged from analysis of the post instructional tests data of this study. All of the children learned some content contributory to the chosen objective but the content which was learned on the lower grade levels differed in the manner indicated from that which was learned on higher grade levels.

Three characteristics which are inherent in the data of this study may be used as criteria for guidance in grade placement. They are as follows:

A. The concepts needed for the associations which were made on the lower grade levels depended upon few experiences which were easily given and acquired.

B. The concepts needed for the associations which were made on the higher grade levels depended upon series of experiences which were not so easily presented or acquired.

C. More concepts were associated in the elements of the higher grade levels.

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ELECTROMAGNETIC INDUCTION

BY C. W. BATDORF

San Mateo High School, San Mateo, California

In presenting a matter relating to electromagnetic induction, we may employ either the old or the new terminology and conceptions, without apology. I am not certain that this analogy is novel, but I do not recall having met with it anywhere.

According to our convention, the lines of force come out from the *N*-pole of a magnet, and pass through the surrounding space to the *S*-pole, and back through the magnet to the *N*-pole, forming closed loops. Hence we may think of the lines of force as being paid out at the *N*-pole, and disappearing into the *S*-pole.

Since a conductor carrying a current has lines of force encircling it transversely, what more natural than to imagine that if these encircling lines could be produced by mechanical means, they would cause a current to flow?

At this point a simple analogy may help students to visualize what may be taking place when a conductor cuts across lines of force. Let the left hand, representing the *N*-pole, hold one end of a suitable string, such as a shoe lace, and let the string extend downward to some object representing the *S*-pole. The end of the string might be lightly fastened to this *S*-pole, the string then representing a line of force. Then with the right hand,

strike with a rod across the string a little below its mid-point, and the *S*-pole end of the string will break loose and wrap around the rod; and the wrapping motion will always take place in the conventional direction of the lines of force about a conductor carrying an induced current. Strike the rod across the string in the opposite direction, and the wrapping will be in the opposite direction, representing an e.m.f. and current in the opposite direction.

If the rod is moved slowly, the end of the string will wrap around it but once, illustrating a small e.m.f. As the rod is moved more rapidly, more and more of the turns of the string will wrap around it, illustrating the increase in e.m.f. as more lines are cut per second.

Thus far the analogy applies to generator action; but now let the string be held in the right hand as the *N*-pole, and the rod in the left hand, and strike across the rod with the string. If interference is properly avoided, the string will wrap around the rod as before, and again in the direction of the lines of force. Striking the string across the rod in the opposite direction will again serve to reverse the direction of all the elements concerned in the action.

Striking the string across the stationary conductor is analogous to the springing out and collapsing of lines of force as the current is made and broken in the induction coil action.

Of course we do not know but what it is the *N*-pole end that breaks loose and wraps around the conductor in the opposite direction, so that the *S*-pole of the exploring needle marks the direction of the wrapping. But even so, the string analogy can be made to fit equally well.

And then again, perhaps we should assume that the moving conductor, together with the action of the line of force in seeking to re-establish itself, results in tearing loose the *N*-pole end as well as the *S*-pole end, and that the two ends wrap themselves around the conductor. To have our analogy represent this action, use a string some ten or fifteen inches long, with a knot, or a small weight, fastened at each end. Suspend the string from one end with the left hand, and strike the rod smartly across its mid-point, freeing the upper end of the string at the instant the rod strikes. To prevent interference, the hand holding the string might be drawn in a little toward the body just a moment before the approaching rod makes contact. The string will then be thrown off the vertical, and the two free ends

will coil rapidly around the rod in opposite directions, without interfering with each other.

I have found that this analogy, when properly used and applied, appeals to my students, and helps them to visualize the action involved, in the conventional treatment of electromagnetic induction.

PROGRAM
OF CONVENTION OF
CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, INC.

Palmer House, Chicago

November 29 and 30, 1935

ANNOUNCEMENTS

Railroad Rates

No direct concessions in railroad rates have been arranged for this meeting. However, most Railroad Companies offer Thanksgiving rates, and many Companies will give rates to the International Live Stock Exhibition which is being held in Chicago at the same time. Avail yourselves of such rates.

Headquarters

The Palmer House has been designated as the official headquarters. All meetings, banquets, luncheons, exhibits, and convention functions will be held there. Information and registration desks will be in the south corridor on the fourth floor; exhibits in the foyer connecting the south corridor with the grand ballroom in which the banquet and general meetings will be held. Section meetings are assigned in near-by rooms.

Location

The PALMER HOUSE is located on Wabash Avenue between Monroe and Adams Streets. Local transportation on the Elevated—the "Adams and Wabash" station on the Loop. Car Parking—Palmer House Garage; Grant Park 25¢; Parking at Monroe Street; Free Parking on the Lake Front from Monroe Street.

Rates

Hotel rates at the Palmer House are:

Single rooms—$3.00, $3.50, $4.00, $4.50, $5.00, $6.00
Double rooms, double beds—$5.00, $6.00, $7.00, $8.00, $9.00, $10.00
Double rooms, twin beds—$6.00, $7.00, $8.00, $9.00, $10.00
Rooms accommodating four persons—$2.50 per person, per day.
Rooms accommodating four persons—$2.00 per person, per day
Suites, single occupancy—$10.00 and up
Suites, double occupancy—$12.00 and up

All rooms are large and airy and are equipped with either tub or shower bath.

At other hotels: all rooms with bath—rates given are *per person.*

	Single Room	*Double Room*	*Three or More*
Congress—Michigan Ave. & Congress St.	$3.00	$2.50	$2.00
Great Northern—Jackson Blvd. & Dearborn St.	$2.00	$1.50	$1.50
LaSalle—LaSalle & Madison Sts.	$2.50 & up	$2.00 & up	$1.50 & up
Morrison—79 W. Madison St.	$2.50	$2.00	$1.50 & up
Sherman—Clark & Randolph Sts.	$2.50 & up	$2.25 & up	$1.50 & up
Stevens—Michigan Ave. & Balbo St.	$2.50–$5.00	$2.00–$3.50 Twin beds, $5.00–$10.00	

YMCA—826 S. Wabash Ave.—rooms with bath $1.75 to $2.00; rooms with running water only $.75 to $1.00. Accommodations for both men and women.

GENERAL PROGRAM

Friday, November 29, 1935

Palmer House, Chicago, Illinois

Admission by ticket or membership card

MORNING

GENERAL SESSION—Grand Ball room—Fourth Floor—9:00 A.M.

9:00 *Music,* Wright Junior College Male Ensemble, Hyacinth Glomski, Director.
9:30 *Address of Welcome,* Charles M. Turton.
9:45 *Response for the Association,* Joel Hadley Shortridge, High School, Indianapolis, Indiana.
10:00 *Science in the New Junior Colleges,* Wm. Bogan, Superintendent of Schools, Chicago, Illinois.
10:30 *The Real Meaning of Conservation* (Illustrated), S. A. Campbell, Conservationist, River Forest, Illinois.
11:15 *The Relation of Mathematics to Art, Poetry, and Music,* Dr. George D. Birkhoff, Harvard University, Cambridge, Massachusetts.
12:00 *Adjournment.*

NOON

Those wishing to have lunch at the Palmer House are advised to consult the menu cards at the information desk. The clerk at this desk will be glad to make reservations for you.

GENERAL PROGRAM

Friday, November 29, 1935

Palmer House, Chicago, Illinois

AFTERNOON

SECTION MEETINGS—2:00–4:30 P.M.
EXHIBITS—Foyer—Fourth Floor—4:00–6:00 P.M.

ANNUAL RECEPTION—Foyer—Fourth Floor—5:00–6:00 P.M. Sponsored by Representatives from the Women's Mathematics Club of Chicago and Vicinity.

EVENING

Admission by ticket or membership card

ANNUAL DINNER—Grand Ball room—Fourth Floor—6:00 P.M.

6:00 *Dinner Served*, Tickets $1.50. Purchase your tickets at the registration desk.

8:00 *Toastmaster*, O. D. Frank, University of Chicago High School, Chicago, Illinois.

8:30 *The Importance of the Scientific Study of Wood*, Dr. Arthur Koehler, U. S. Forest Products Laboratories, Madison, Wisconsin.

GENERAL PROGRAM

Saturday, November 30, 1935

Palmer House, Chicago, Illinois

Admission by ticket or membership card

MORNING

ANNUAL BUSINESS MEETING—Grand Ball room—Fourth Floor—8:15–9:00 A.M.

All members of the Association are eligible to attend this meeting. Your attendance is expected. Please be on time.

GENERAL SESSION—Grand Ball room—Fourth Floor—9:00 A.M.

9:00 *Music*, Junior College Choral Club, C. H. Haberman, Director, J. Sterling Morton Junior College, Cicero, Illinois.

9:30 *The Value of Animal Experimentation*, Dr. Arno B. Luckhardt, University of Chicago, Chicago, Illinois.

10:00 *The Future of Mathematics*, Dr. E. J. Moulton, Dean of Graduate School, Northwestern University, Evanston, Illinois.

10:45 *Selected Topics in Acoustics, with Experiments*, Dr. F. R. Watson Acoustics Laboratories, University of Illinois, Urbana, Illinois.

12:00 *Adjournment.*

NOON

LUNCHEON—Victorian Room—First Floor—12:30–2:00 P.M.

All newly elected officers, new and retiring members of the Board of Directors, the Editor and the Business Manager of the *Journal* are expected to be present at this luncheon.

Tickets 85¢.

SECTION MEETINGS

Biology

Palmer House—Private Dining Room 14—Club Floor

Friday, November 29, 2:00 P.M.

Admission by ticket or membership card

Orra Olive Dunham, Chairman, Collinwood High School, Cleveland Ohio.

Harvey Milford, Vice-Chairman, Edwin Denby High School, Detroit, Michigan.
J. W. Kendrick, Secretary, Arsenal Technical High School, Indianapolis, Indiana.

PROGRAM

Appointment of Nominating Committee.

2:00 *Preparation of Museum Exhibits*—(Illustrated), Earl C. Wright, Curator of Museum Exhibits, Chicago Academy of Science, Chicago, Illinois.
2:30 *Biological Science in the Junior Colleges*, Jerome Isenbarger, Wright Junior College, Chicago, Illinois.
3:00 *Election of Officers.*
3:05 *The Physiology of Nerves*, Dr. Theodore E. Boyd, Head of Physiology Department, Loyola University School of Medicine, Chicago, Illinois.
3:35 *Termite Society* (Illustrated), Dr. Alfred E. Emerson, Department of Zoology, University of Chicago, Chicago, Illinois.

Chemistry

Palmer House—Club Lounge—Club Floor

Friday, November 29, 2:00 P.M.

Admission by ticket or membership card

M. J. W. Phillips, Chairman, High School, West Allis, Wisconsin.
Allan R. Stacy, Vice-Chairman, Washington High School, Indianapolis, Indiana.
Jesse L. Van Horn, Secretary, Lincoln High School, Cleveland, Ohio.

PROGRAM

Appointment of Nominating Committee.

2:00 *Demonstration of the Refining of Petroleum*, F. W. McCurry, Vice-President in Charge of Manufacturing, Derby Oil Company, Wichita, Kansas. (This will be a demonstrative lecture using equipment made by Mr. McCurry when he was Chief Chemist of the Derby Oil Company.)
3:00 *Election of Officers.*
3:05 *Modern Trends in Teaching as Applied to Chemistry*, Dr. W. W. Theisen, Assistant Superintendent of Schools, Milwaukee, Wisconsin.
3:40 *Physical Science in the Junior Colleges*, Dr. Nicholas Cheronis, Wright Junior College, Chicago, Illinois.

Elementary Science

Palmer House—Private Dining Room—Third Floor

Friday, November 29, 2:00 P.M.

Admission by ticket or membership card

Florence G. Billig, Chairman, College of Education, Wayne University, Detroit, Michigan.
Lillian Hethershaw, Vice-Chairman, Drake University, Des Moines, Iowa.
Geraldine Shontz, Secretary, State Teachers College, Terre Haute, Indiana.

PROGRAM

Appointment of Nominating Committee.

2:00 *A Point of View in Science Teaching*, Dr. Otis W. Caldwell, Professor Emeritus, Teachers College, Columbia University, New York City.

2:30 *Science in the Elementary School Program*, Glenn Blough, Supervisor Elementary Science, Michigan State Normal School, Ypsilanti, Michigan.

3:00 *The Radio and Elementary Science*, Mary Melrose, Supervisor of Elementary Science, Cleveland Public Schools, Cleveland, Ohio.

3:30 *Visual Materials in the Teaching of Science in Elementary Schools*, Paul Edwards, Supervisor of Science and Visual Education, Chicago Public Schools, Chicago, Illinois.

4:05 *General Discussion*, led by Bertha M. Parker, University Elementary School, The University of Chicago, Chicago, Illinois.

General Science

Palmer House—Exhibit Hall—Fourth Floor

Friday, November 29, 2:00 P.M.

Admission by ticket or membership card

Leonard B. Johnson, Chairman, Roosevelt Junior High School, Milwaukee, Wisconsin.

Alma Thomas, Vice-Chairman, Audubon Junior High School, Cleveland, Ohio.

Carl F. Hanske, Secretary, Manual Training High School, Indianapolis, Indiana.

PROGRAM

Appointment of Nominating Committee.

2:00 *What Phases of Astronomy Should Best be Taught in General Science for the Ninth Grade?*, Dr. Georges VanBiesbroeck, Professor of Astronomy, Yerkes Observatory, The University of Chicago, Williams Bay, Wisconsin. Dr. VanBiesbroeck's report will be illustrated with slides.

2:30 *Problems and Techniques in a General Science Class Room*, Ira C. Davis, University High School, Madison, Wisconsin.

3:00 *Election of Officers.*

3:05 *The Anti-Vivisection Propaganda and Its Relation to the Teaching of Science in our Public Schools.* Joseph E. Teder, Lake View High School, Chicago, Illinois.

3:35 *General Discussion*, led by Miss Alma Thomas, Audubon Junior High School, Cleveland, Ohio.

Geography

Palmer House—Private Dining Room 9—Third Floor

Friday, November 29, 2:00 P.M.

Admission by ticket or membership card

Helen A. Southgate, Chairman, Isaac Elston High School, Michigan City, Indiana.

Howard Wright, Vice-Chairman, Shortridge High School, Indianapolis, Indiana

Virgil Petty, Secretary, Berger School, South Holland, Michigan.

PROGRAM

Appointment of Nominating Committee.

2:00 *State Aid in Teaching Earth Science*, Dr. Don Carroll, Associate Geologist, State of Illinois.

2:30 *Human Geography as Related to the Zonation of Vegetation in the San Francisco Mountain Region* (Illustrated), H. O. Lathrop, Illinois State Normal University, Normal, Illinois.

3:00 *Election of Officers.*

3:05 *In Viking Land* (Illustrated), Mabel Engstrom, Isaac Elston High School, Michigan City, Indiana.

3:35 *The Thirteen Month Calendar.*

Mathematics

Palmer House—Grand Ball Room—Fourth Floor

Friday, November 29, 2:02 P.M.

Admission by ticket or membership card

J. Russell McDonald, Chairman, J. Sterling Morton High School, Cicero, Illinois.

C. J. Leonard, Vice-Chairman, Southeastern High School, Detroit, Michigan.

Buelah Shoesmith, Secretary, Hyde Park High School, Chicago, Illinois.

PROGRAM

Appointment of Nominating Committee.

2:00 *Geometrical Constructions without the Compasses*, Walter H. Carnahan, Shortridge High School, Indianapolis, Indiana.

2:30 *Non-Technical Functions of Mathematics*, Dr. Mayme I. Logsdon, Associate Professor of Mathematics, University of Chicao, Chicago, Illinois.

3:00 *Election of Officers.*

3:05 *Improved Instruction vs. Curriculum Tinkering*, Walter W. Hart, Associate Professor of Mathematics, University of Wisconsin, Madison, Wisconsin.

3:35 *General Discussion.*

Physics

Palmer House—Club Dining Room—Club Floor

Friday, November 29, 2:00 P.M.

Admission by ticket or membership card

James P. Coyle, Chairman, Lane Technical High School, Chicago, Illinois.

Emil Massey, Vice-Chairman, Central High School, Detroit, Michigan.

Charles L. Brosey, Secretary, Arsenal Technical High School, Indianapolis, Indiana.

PROGRAM

Appointment of Nominating Committee.

2:00 *Some Effective Demonstrations in Elementary Physics*, Dr. Glenn M. Hobbs, Head of Technical Department, W. M. Welch Scientific Company, Chicago, Illinois.

2:30 *Adapting Laboratory Work to a Five-Period Schedule*, Dr. Wilbur L. Beauchamp, Assistant Professor of Education, University of Chicago, Chicago, Illinois.
3:00 *Election of Officers.*
3:05 *Showing of University of Chicago Physical Science Talking Pictures*, University of Chicago Press, Chicago, Illinois. Introduction by Dr. Harvey B. Lemon, Physics Department, University of Chicago, Chicago, Illinois.
3:45 *Methods of Accomplishing Laboratory Work in a Single Period*, H. Clyde Krenerick, North Division High School, Milwaukee, Wisconsin.
4:10 *The Effects of Modern Physics on our Elementary Instruction*, Professor N. Henry Black, The Physics Laboratories, Harvard University, Cambridge, Massachusetts.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1389. *Daniel Finkel, Maxwell Reade, Brooklyn, N. Y., Charles C. D'Amico, Albion, N. Y.*

1391. *Daniel Finkel, Maxwell Reade, Brooklyn, N. Y. A. R. Haynes, Tacoma, Wash., Charles C. D'Amico, Albion, N. Y.*

1394. *Proposed by Maxwell Reade, Brooklyn, N. Y.*

Show that if a, b, c are positive and real

(a) $\frac{1}{2}(a+b+c)-\frac{ab}{a+b}-\frac{bc}{b+c}-\frac{ac}{c+a}$ can never be negative.

(b) For (a) to hold must a, b, c be real?

Solution by Aaron Buchman, Buffalo, N. Y.

(a) Let a, b, c be positive and real. Then $(a-b)^2 \geqq 0$.
Expanding and adding $4ab$, $a^2+2ab+b^2 \geqq 4ab$.

Factoring and dividing by $4(a+b)$, $\frac{a+b}{4} \geqq \frac{ab}{a+b}$, from which

1. $\frac{a+b}{4}-\frac{ab}{a+b} \geqq 0$. Similarly
2. $\frac{b+c}{4}-\frac{bc}{b+c} \geqq 0$, and
3. $\frac{c+a}{4}-\frac{ac}{c+a} \geqq 0$.

Adding the members of equations 1, 2, 3,

4. $\frac{1}{2}(a+b+c)-\frac{ab}{a+b}-\frac{bc}{b+c}-\frac{ac}{c+a} \geqq 0$.

(b) Expression (4) is satisfied by values for a, b, c, which are not all real. For instance, take the cube roots of unity, thus $a=1$, $b=-\frac{1}{2}+\frac{\sqrt{3}}{2}i$, $c=-\frac{1}{2}-\frac{\sqrt{3}}{2}i$ which make the left side of (4) equal to zero.

Therefore the answer to (b) is no.

A solution to the first part was also offered by Charles C. D'Amico, Albion, N. Y. and the proposer.

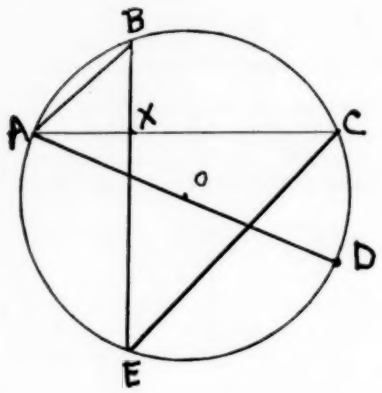
1395. *Proposed by Cecil B. Read, University of Wichita, Kansas.*

The sum of the squares of the segments of two perpendicular chords of a circle is equal to the square of the diameter.

Solution by Frank DuBois, Lewis and Clark High School, Spokane, Washington

Given: Circle O and any 2 perpendicular chords, AC and BE.
To Prove: $AX^2+BX^2+CX^2+EX^2=AD^2$.
Constructions: Draw diameter AD through O and lines AB, BD, CE.
1. $AX^2+BX^2=AB^2$ and $EX^2+CX^2=CE^2$, adding
2. $AX^2+BX^2+CX^2+EX^2=AB^2+CE^2$
3. $\overset{\frown}{AB}+\overset{\frown}{BD}=180°$ and $\overset{\frown}{AB}+\overset{\frown}{CE}=180°$. Hence
4. $\overset{\frown}{BD}=\overset{\frown}{CE}$ and chord $BD=CE$
5. ABD is a right triangle, hence
6. $AD^2=AB^2+BD^2$, also
7. $AD^2=AB^2+CE^2$. Hence from (2)
8. $AX^2+BX^2+CX^2+EX^2=AD^2$.

Solutions were also offered by Charles C. D'Amico, Albion, N. Y., Maxwell Reade, Brooklyn, A. R. Haynes, Tacoma, Wash., H. L. Juditz, New York City, Benjamin Braverman, New York City, W. E. Buker, Leetsdale, Pa., John K. Fisher, La Grande, Wash., Hyman Zalosh, New York City, Aaron Buchman, Buffalo, N. Y., David Finkel, Brooklyn, and the proposer.



1396. *Proposed by Norman Anning, University of Michigan.*

Arrange in descending order of magnitude, without finding numerical values, the following functions: cot 18°, csc 18°, 2 cot 36°, 2 csc 36°, and 4 cos 36°.

Solution by H. Leo Juditz, New York City

Evaluating the functions for comparison purposes as indicated below we obtain:

1. $\csc 18° = \dfrac{1}{\sin 18°} = \dfrac{2 \cos 18°}{\sin 36°}$

2. $4 \cos 36° = \dfrac{4 \cos 36° \sin 36°}{\sin 36°} = \dfrac{2 \sin 72°}{2 \sin 18° \cos 18°} = \dfrac{1}{\sin 18°}$

   Hence $\csc 18° = 4 \cos 36°$

3. $2 \csc 36° = \dfrac{2}{\sin 36°}$. From (1) since $\cos 18° < 1$, $\csc 18° < 2 \csc 36°$

4. $\cot 18° = \dfrac{\cos 18°}{\sin 18°} = \dfrac{2 \cos^2 18°}{\sin 36°}$. From (1), since $\cos 18° > \cos^2 18°$, $\csc 18° > \cot 18°$.

5. $2 \cot 36° = \dfrac{2 \cos 36°}{\sin 36°} = \dfrac{2 (\cos^2 18° - \sin^2 18°)}{2 \sin 18° \cos 18°} = \dfrac{\cos 18°}{\sin 18°} - \dfrac{\sin 18°}{\cos 18°}$

   From (4), since $\dfrac{\sin 18°}{\cos 36°}$ is positive, $2 \cot 36° < \cot 18°$.

   Hence the magnitude in descending order is:

$$2 \csc 36°, \csc 18° = 4 \cos 36°, \cot 18°, 2 \cot 36°.$$

Solutions were also offered by Hyman Zalosh, New York City, and Frank Du Bois, Spokane, Wash.

1397. *Proposed by Richard A. Miller, University of Mississippi*

In a triangle the circumradius is equal to the inradius divided by the sum of the cosines of the angles of the triangle diminished by one.

Solution by the proposer

Draw $ID \perp AC$

Proof: Let $AC=b=AD+CD$, $ID=r$

$$AD=r\cot\frac{A}{2},\ CD=r\cot\frac{C}{2}.\ \text{Hence}$$

$$(1)\quad b=r\left[\cot\frac{A}{2}+\cot\frac{C}{2}\right]=r\left[\frac{\cos\frac{A}{2}}{\sin\frac{A}{2}}+\frac{\cos\frac{C}{2}}{\sin\frac{C}{2}}\right].$$

$$(2)\quad b\sin\frac{A}{2}\sin\frac{C}{2}=r\left[\sin\frac{C}{2}\cos\frac{A}{2}+\sin\frac{A}{2}\cos\frac{C}{2}\right]=r\sin\left[\frac{A}{2}+\frac{C}{2}\right].$$

$$=r\sin\left[90-\frac{B}{2}\right]=r\cos\frac{B}{2}.$$

$$(3)\quad r=\frac{b\sin\frac{A}{2}\sin\frac{C}{2}}{\cos\frac{B}{2}}.$$

From trigonometry

$$(4)\quad b=2R\sin B=4R\sin\frac{B}{2}\cos\frac{B}{2}.$$

$$(5)\quad r=4R\sin\frac{A}{2}\sin\frac{B}{2}\sin\frac{C}{2}.$$

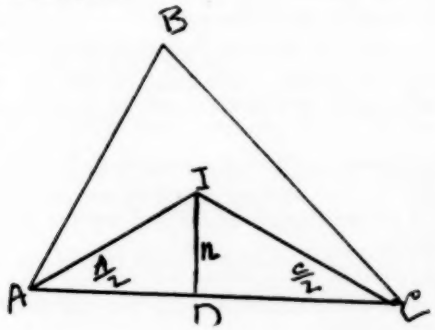
By trigonometry—$A+B+C=180°$, and also,

$$4\sin\frac{A}{2}\sin\frac{B}{2}\sin\frac{C}{2}=\cos A+\cos B+\cos C-1$$

$$(6)\quad \therefore r=R[\cos A+\cos B+\cos C-1].$$

$$R=\frac{r}{\cos A+\cos B+\cos C-1}.$$

Solutions were also offered by Maxwell Reade, Brooklyn, Charles C. D'Amico, Norman Anning, University of Michigan, Hyman Zalosh, New York City, A. R. Haynes, Tacoma, Kenneth Carlson, Kearney, Neb., W. E. Buker, Leetsdale, Pa.



1398. *Proposed by Julius Freilich, Brooklyn.*

Prove: $\cos 12 \cdot \cos 24 \cdot \cos 36 \cdot \cos 48 \cdot \cos 60 \cdot \cos 72 \cdot \cos 84 = (\frac{1}{2})^7$, the angular unit being the degree.

Solution by Simon L. Berman, Brooklyn

Multiply the left member of the proposed equation by $\frac{2^7 \sin 12 \sin 36}{2^7 \sin 12 \sin 36}$

Then, in numerator, $2 \sin 12 \cos 12 = \sin 24$;
$2 \sin 24 \cos 24 = \sin 48$; $2 \sin 48 \cos 48 = \sin 96 = \sin 84$;
$2 \sin 84 \cos 84 = \sin 168 = \sin 12$.
Also, $2 \sin 36 \cos 36 = \sin 72$; $2 \sin 72 \cos 72 = \sin 144 = \sin 36$.
Since $\cos 60 = \frac{1}{2}$, the numerator becomes unity, and the denominator becomes 2^7. $\therefore$ the problem is solved since $\frac{1}{2^7} = (\frac{1}{2})^7$.

Solutions were also offered by Hyman Zalosh, New York City, Cecil B. Read, Wichita, Kan., John N. Meighan, Clyde, Ohio, Maxwell Reade, Brooklyn, Norman Anning, University of Michigan, W. E. Buker, Leetsdale, Pa., H. L. Juditz, New York City, A. R. Haynes, Tacoma, Wash., and the proposer.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below.

1395. Doris Moore and Charles Lappley, Phineas Banning, H. S. Wilmington, Calif., Olney High Math. Club, Philadelphia.

PROBLEMS FOR SOLUTION

1412. *Proposed by Samuel I. Jones, Nashville, Tenn.*

Given triangle ABC and a point, P, not on a side. It is required to draw a line from P bisecting the given triangle.

1413. *Proposed by Maxwell Reade, Brooklyn*

In triangle ABC, AF, BD, and CE are cevians meeting at O. AF is perpendicular to BC, BD meets FE at K, CE meets FD at G, and ED meets BC at T. Prove T, K and G are collinear.

1414. *Proposed by Amory R. Haynes, Lincoln High School, Tacoma, Wash.*

A cow is tethered to a post of the fence enclosing a five-acre circular field. What is the length of tether so that an area of one acre may be grazed over?

1415. *Proposed by Dewey C. Duncan, Compton, Calif.*

Find the length of the common chord of two intersecting circles of lengths a and b, if the segment of the line of centers common to the two circles is $2c$ in length.

1416. *Proposed by Cecil B. Read, Wichita, Kan.*

In a given circle inscribe a triangle such that its three sides shall pass through three given points.

1417. *Proposed by a Student.*

Prove: $(n+1)^{r+1}-(n+1)=(r+1)\ S_n{}^r+\frac{(r+1)r}{1.2}\ S_n{}^r+\cdots+(r+1)\ S_n{}^1$, if $S_n{}^r=1^r+2^r+3^r+\cdots+n^r$.

SCIENCE QUESTIONS

November, 1935

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

Readers of School Science and Mathematics are asked to contribute: Questions, Answers, Comments, Suggestions—Whatever is new or interesting in the teaching of Science.

Your classes and yourself are invited to join the GQRA (Guild Question Raisers and Answerers). More than 100 others have already been admitted to membership by answering a question or proposing one that is published.

ARGUMENT OVER GAS METER PROBLEM

700. *Letter from Jerome L. C. Formo, Augsburg College, Minneapolis, Minn. (Elected to GQRA, No. 102.)* (This question with comments and answers will be found in SCHOOL SCIENCE AND MATHEMATICS in the April, May and June, 1935, numbers.)

As I was looking through some of last year's school books I came upon a GQRA problem which I had copied from SCHOOL SCIENCE AND MATHEMATICS. I remember now that I also saw an answer to that problem (No. 700) with which I was not satisfied. Perhaps this letter is very, very late, but nevertheless I must write it to clear my conscience of whatever may be bothering it in regard to the printed solution.

A, *B*, *C*, & *D* are 4 gas meters
A & *B* are in the attic
C & *D* are in the basement
A & *C* are at 70°
B & *D* are at 35°

Cost of gas is $1.00 per 1000 cu. ft.
A is at 70° & reduced pressure (due to altitude of attic)
B is at 35° & reduced pressure
C is at 70° & higher pressure
D is at 35° & higher pressure

The gas which is at the lowest temperature and highest pressure (and therefore greatest molecular concentration) should give the most heat per cu. ft.

D is the gas meter which fulfills this requirement. Therefore the owner of meter *D* gets the most for his money.

PACKARD SIMPLIFIES QUESTION

721. *Proposed by John C. Packard, Brookline High School, Brookline, Mass. (GQRA, No. 1.)*

Would it make any difference in the gas bill if the meters were in the attic instead of in the basement?

TRICKING THE GAS COMPANY

722. *Proposed by J. C. Packard.* (*GQRA, No. 1.*)

Could a man reduce his gas bill by packing ice around the gas pipe which leads to his meter?

GOLD

The following questions have been asked (some cases in slightly different form):

713. What is the volume of the U. S. gold dollar?

620. What is the specific gravity of gold?

621. How large a cube would a million dollars in gold make?

Answers by M. M. O'Reilley, Acting Director of the Mint, Treasury Department, Washington, D. C. (*Elected to GQRA, No. 93.*)

Receipt is acknowledged of your letter of April 30th, addressed to the Secretary of the Treasury and referred to this Bureau for attention.

The volume of the United States gold dollar of 15.23809 grains is .0035114 cubic inches.

The specific gravity of fine gold is 19.3. The specific gravity of the gold in the United States gold dollar is 17.1 in an alloy of 90% gold and 10% copper.

One million dollars in fine gold would make a cube 14.11 inches on each of six sides.

One million dollars in standard gold (900 gold and 100 copper) will make a cube 15.2 inches on each side.

Also answered by Charles C. D'Amico (*GQRA, No. 49.*)

PUZZLERS AND TRICK QUESTIONS

From newspaper clippings

723. How long is a string?

724. How far can a dog run into the woods?

Some time ago the Editor sent these questions to the Philippines—Miss Luz A. Santos (GQRA, No. 43), Rezal High School, Pasig, P. I. Her classes took to them in earnest and she sent in "the best answers." Here are some of them:

Armando Pasco (*GQRA, No. 103*)

"The length of a string is equal to the number of times a unit of length is contained between the two ends of the string when it is stretched."

Borgonio Cruz (*GQRA, No. 104*)

The dog can run "one-half the diameter of the woods, for if he goes farther than the center of the woods, he would be nearer to one end, and that is not the farthest."

Fernando Mañzalas (*GQRA, No. 105*)

"A dog can run from the center of the woods to the exterior of the woods."

Deogracias Castañeda (GQRA, No. 106)

"The length of the string is equal to twice one-half of the length of the string."

Also answered by: Sergio M. Bautista (GQRA, No. 107); Vivencio R. Ceñidoza (GQRA, No. 108); Enfracio C. Quianibao (GQRA, No. 109); Achilles Junitas (GQRA 110); Bienvenido F. Miranda (GQRA 111)

725. *College Entrance Examination Board—Physics—1935. Would the prospect of a good stiff examination by an outside Examining body help you to do better work?*

PHYSICS

Wednesday, June 19 **2 P.M. Two hours**

Answer *nine* questions as indicated below.
State the units in which each answer is expressed.
No credit will be given for problems on this paper unless the methods of reaching the results are clearly shown.
Number and letter each answer to correspond with the question selected.
Questions in Part II carry slightly more credit than those in Part I.

PART I

Answer all questions in this part.

1. *a*) Explain how to prove experimentally that there are two kinds of electrical charges.
   b) Explain how to give an electroscope a permanent charge by induction.
2. Three balloons inflated with hydrogen, identical except for the features listed below, are released for flight into the upper atmosphere. Compare the ultimate heights reached, giving reasons for your answers.
   a) Balloon freely and indefinitely expansible.
   b) Balloon of definite size and sealed gas-tight.
   c) Balloon of definite size but with valve through which gas may escape when internal pressure is greater than external.
3. *a*) What is (1) specific heat, (2) heat of fusion?
   b) A 1000-gram block of metal at a temperature of 300°C. is put into 100 grams of water at 0°C. in a well-insulated calorimeter weighing 100 grams and having a specific heat of 0.1. The resulting temperature is 71°C. What is the specific heat of the metal?
4. A uniform beam 12 feet long and weighing 100 pounds is laid across two parallel rails placed three feet from the ends of the beam. A man weighing 150 pounds stands on the beam directly over one rail.
   a) Find the force on each rail.
   b) How far toward the nearer end of the beam can the man move without tilting the beam?
5. To a six-volt automobile battery are connected in series two resistances, R_1 and R_2.
   a) If the current is 3 amperes and potential difference across R_1 is 2.4 volts, across R_2, 3.6 volts, calculate the values of the two resistances.
   b) If another resistance is connected in parallel with R_2, state whether current and potential differences in R_1 and in R_2 would increase, decrease, or remain unchanged. Give reasons.

6. A beam of white light is directed perpendicularly upon a slab of glass with parallel sides, 100 centimeters thick.
   a) If the light is suddenly flashed on, which color will emerge first, red or violet?
   b) What will be the distance between them when the red emerges? Choose the correct indexes of refraction for the two colors from the following numbers: 1.56, 3.75, 0.8, 1.53. Velocity of light =300,000,000 meters per second in air.

PART II

Select three questions from this part.

7. If two cars start in the same direction from rest, the first at a time slightly before the other, and if both maintain the same constant acceleration, will they remain the same distance apart or not? Explain the physical reasoning by which you arrive at this answer, assuming reasonable numerical data if you wish.
8. *a*) What is sound? How is it transmitted?
   b) A stone is dropped into a mine 1024 feet deep, on a day when the temperature is 68°F., and lands in water at the bottom. How long after the stone is dropped is the sound heard?
9. A 120-pound boy in a swing with 20-foot ropes is pulled aside a horizontal distance of 12 feet.
   a) What horizontal force is necessary to hold him in this position?
   b) What is the tension on the ropes?
   c) What is the tension on the ropes at the instant he has been released?
10. *a*) State in words a physical law or principle associated with each of the following names: Archimedes, Newton, Boyle, Pascal, Ohm.
    b) State three names associated with important contributions to the subject of physics since 1890, and in each case state the subject of his contribution.
11. Given an empty can, a foot rule, and a large vessel of water, how might you proceed to find the specific gravity of a stone small enough to go in the can?
12. To crank a certain car for successful starting requires an average expenditure of $\frac{1}{2}$ horse power.
    a) If the electromotive force of the starter batteries is 6 volts, what is the least current that must be drawn from the battery to start the car?
    b) What conclusions may be drawn from this answer concerning the specifications of the battery, starting motor, and connecting wires?
    c) If, on attempting to use the starting motor, it should jam and not revolve, would the current from the battery be greater or less than the above estimate? Why?

JOIN THE GQRA!

BOOKS AND PAMPHLETS RECEIVED

Plane and Spherical Trigonometry, by Lyman M Kells, Associate professor of Mathematics, U. S. Naval Academy; Willis F. Kern, Assistant Professor of Mathematics, U. S. Naval Academy; and James R. Bland, Assistant Professor of Mathematics, U. S. Naval Academy. First Edition.

Cloth. Pages xiv+269+vii+115. 15×23 cm. 1935. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.50.

Laboratory Exercises in Inorganic Chemistry, by G. H. Cartledge, and H. M. Woodburn, The University of Buffalo. Cloth. Pages v+149. 14×20.5 cm. 1935. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.00.

The Work of Scientists, by Edith M. Patch, and Harrison E. Howe. Book Six. Cloth. Pages viii+488. 14×18.5 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 78 cents.

Intermediate Algebra, by Raymond W. Brink, Professor of Mathematics in the University of Minnesota. Cloth. Pages xii+268. 13×20 cm. 1935. D. Appleton-Century Company, 35 West 32nd Street, New York, N. Y. Price $1.35.

Sahara, The Great Desert, by E. F. Gautier, Professor in the University of Algiers, and Authorized Translation by Dorothy Ford Mayhew, Librarian, Institute of Geographical Exploration, Harvard University. Cloth. Pages xvii+264. 15.5×23.5 cm. 1935. Columbia University Press, 2960 Broadway, New York, N. Y. Price $3.75.

Descriptive Geometry, by Frank W. Bubb, Associate Professor of Applied Mathematics, Washington University, Saint Louis. Cloth. Pages xv+234. 14×21.5 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.50.

Practical Shop Mathematics, Volume I—Elementary, by John H. Wolfe, Supervisor of Apprentice School, Ford Motor Company, and Everett R. Phelps, Associate Professor of Physics, Wayne University. First Edition. Cloth. Pages xi+331. 12×20 cm. 1935. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.20.

First and Second Year Algebra, Combined, by Herbert E. Hawkes, Professor of Mathematics in Columbia University; William A. Luby, Head of the Department of Mathematics in the University of Kansas City; and Frank C. Touton, Professor of Education in the University of Southern California. Cloth. Pages viii+735+vi. 12.5×19 cm. 1935. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.60.

Modern Radio Servicing, by Alfred A. Ghirardi. Cloth. Pages x+1300. 706 Illustrations. 13.5×20.5 cm. 1935. Radio and Technical Publishing Company, 45 Astor Place, New York, N. Y. Price $4.00.

Elements of Projective Geometry, by Emery Ernest Watson, Professor of Mathematics, Iowa State Teachers College, and Margaret Marie Watson. Cloth. Pages v+255. 13.5×19.5 cm. 1935. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $2.60.

A Study Book in General Science, by Wilbur L. Beauchamp, University of Chicago, and Harold H. Miller, Head of Science Department, Benjamin Franklin Junior-Senior High School, Rochester, New York. Teacher's Edition. Paper. Pages viii+331. 20.5×26.5 cm. 1935. Scott, Foresman and Company, 623 South Wabash Avenue, Chicago, Ill. Price 92 cents.

Radio Field Service Data, by Alfred A. Ghirardi. Paper. Pages viii+240. 14×20.5 cm. 1935. Radio and Technical Publishing Company, 45 Astor Place, New York, N. Y. Price $1.50.

Exploring in Physics, by Reginald J. Stephenson, The University of Chicago. Paper. Pages xiv+204. 17×23.5 cm. 1935. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Illinois. Price $1.50.

Directed Activities—I, A Workbook to Guide Pupils in their Study of the World Around Us, by Samuel Ralph Powers, Professor of Natural Sciences, Teachers College, Columbia University; Elsie Flint Neuner, Supervisor of Elementary Science, New Rochelle, New York; and Herbert Bascom Bruner, Professor of Education, Teachers College, Columbia University.

Paper. Pages v+112. 19×27.5 cm. 1935. Ginn and Company, 15 Ashburton Place, Boston Mass. Price 40 cents.

Students Manual in Biology, by Frederick L. Fitzpatrick, Associate Professor of Natural Sciences, Teachers College, Columbia University, New York, and Ralph E. Horton, Chairman of the Department of Science, Seward Park High School, New York City. Paper. 160 pages. 20×28 cm. 1935. Houghton Mifflin Company, 2 Park Street, Boston, Mass. Price 48 cents.

A Manual for Instructors in Civilian Conservation Corps Camps, prepared by the Vocational Division, United States Office of Education, Department of the Interior. Paper. Pages xv+95. 14×23.5 cm. 1935. Superintendent of Documents, Washington, D. C. Price 10 cents.

Agriculture, Outlines of Instruction for Educational Advisers and Instructors in Civilian Conservation Corps Camps, prepared by the Vocational Division, United States Office of Education, Department of the Interior. Paper. Pages x+74. 14.5×23.5 cm. 1935. Superintendent of Documents, Washington, D. C. Price 10 cents.

Emmy Noether, by Hermann Weyl. Paper. 20 pages. Reprinted from Scripta Mathematica, Vol. III, No. 3. July, 1935.

Preliminary Description of the Alpha, Beta, and Gamma Examinations in Mathematics. Paper. 15 pages. College Entrance Examination Board, 431 West 117th Street, New York, N. Y.

What Scientists Say of Leitz Ultropak. Bulletin 17. 31 pages. Bulletin 18 describes the complete line of Leitz Ultropak. 32 pages. Copies can be obtained without charge by writing to E. Leitz, Inc., 60 East 10th Street, New York, N. Y.

Spectrophotometer Assemblies. 8 pages. Bulletin No. 134. Michelson Interferometer and Accessories. 4 pages. Bulletin No. 135. Comparators of Recent Design. 8 pages. Bulletin No. 136. Copies can be obtained by writing to The Gaertner Scientific Corporation, 1201 Wrightwood Avenue, Chicago, Illinois.

BOOK REVIEWS

The Rise of Modern Physics, by Henry Crew, Professor Emeritus of Physics in Northwestern University. Second Edition. Cloth. Pages xix+434. 12.5×18.5 cm. 1935. The Williams and Wilkins Company, Baltimore, Md. Price $4.00.

One of the neglected topics in the field of science education is a presentation of the history of science. Very few colleges and universities offer courses in this subject, leaving their students to glean a mere smattering and very unsatisfactory knowledge of the development of their subject. It would add much to the general interest of the public in science if more attention were given to this subject. Only a very few books on the history of physics are available. Among these Professor Crew's *The Rise of Modern Physics* stands out prominently. In the Preface he points out that the word modern is used as in history "to cover the period subsequent to the renaissance." Professor Crew's broad reading and extensive travel and study in the leading countries of Europe, where physical thought has developed, enable him to appraise the work of each investigator in an impartial manner and to see the significance of details that escape an observer of less experience and discriminating judgment.

Practically all of the first edition has been carried over into the second, but the addition of three new chapters is so important that all who pos-

sess a copy of the first volume will want the new one. The chapter on the origin of modern electrical units deserves particular attention. In fact any suggestion for simplification of our complex and time-wasting systems of electrical units should receive consideration. Dr. Crew has here presented a valuable review of the situation. Another important change is in the illustrations used. The new edition contains much better photographs than the first, omits some of those of less important physicists and adds a few of the great ones of more recent times. This book should be in every science library and is excellent as a text for classes in the history of the development of physical thought. More such courses should be offered in our colleges and universities.

G. W. W.

Daylight, Twilight, Darkness, and Time, by Lucia Carolyn Harrison, Department of Geography and Geology, Western State Teachers College, Kalamazoo, Michigan. Cloth. Pages viii+216. 13×19.5 cm. 1935. Silver Burdett and Company, 39 Division Street, Newark, N. J. Price $1.24.

This is a very interesting and useful little book designed for those who have no knowledge of astronomy. It emphasizes the relation of human affairs to the relative movements of sun and earth; shows how to determine location on earth from position of celestial bodies, gives a brief discussion of time, describes some interesting experiments or observations, and proposes nearly sixty puzzle questions. It is well illustrated and carefully written.

G. W. W.

Introduction to Inorganic Chemistry, by G. H. Cartledge, Head of the Department of Chemistry, The University of Buffalo. First Edition. Pages vii+609. 3×15×21 cm. 52 figures, several cuts and plates, four place log table. Cloth. 1935. Ginn and Company. Price $3.00.

This new text is intended for beginning students in college chemistry. Its approach to the subject is novel. Starting with a brief account of the electrolysis of molten salt the author plunges immediately into the presentation of the modern concepts regarding atoms, molecules and subatomic physics. Crystal structure, Laue diagrams, space lattices, atoms, ions, cathode rays, electrons, radio activity, Moseley's Law, the nucleus, characteristics and structure of atoms and isotopes follow rapidly in brief and elementary form.

Now the author is ready to take up a study of chemistry with a modern background of facts and theory of atoms as a tool. The relation between atomic structure and chemical changes follows and a study of mass relations in chemical change is made. Thus, instead of following the historical order of mass relations and an atomic theory to account for them this text first presents briefly some of the facts and the conclusions in regard to atoms and then shows that the mass relations must necessarily follow out of them. The departure is a bit daring but it is claimed that it has worked well in actual trial upon various classes of students, and it should be given a chance to prove itself. Are some of the rest of us still driving horses hitched to buggies? The remainder of the book does not look so strange to us but we notice that several important subjects have no chapter headings but that they are studied as they naturally come up in connection with other topics (which is the way real research proceeds). Thus there is no chapter on electrochemistry but that subject is repeatedly treated in connection with related matter. Colloid chemistry, radioactivity

and a modicum of organic chemistry are similarly treated. Much attention is given to periodic relationships and this is done largely by an intensive study of a few typical periods dealing with familiar elements.

There is so much of originality in the order of treatment in this text that college professors who have beginning classes will want to make a study of its tactics.

FRANK B. WADE

Laboratory Exercises in Inorganic Chemistry, by G. H. Cartledge and H. M. Woodburn, The University of Buffalo. First Edition. Pages v+149. 1.25×14.5×21 cm. 23 figures. Cloth. 1935. Ginn and Company. Price $1.00.

This Laboratory Manual is designed to accompany Introduction to Inorganic Chemistry by one of the authors. Since the order of events in the text book is quite different from the usual order the manual was needed for use with the text. The number of experiments is not large but many of them are longer than the usual ones. A large number of "preparations" gives an opportunity to apply and study fundamental principles. While no "preparations" of the common gases are made as solitary experiments they are all prepared as necessary steps in the preparation of other substances. As is the case with the textbook, so, with this laboratory manual, much of originality of treatment is in evidence. Students who use it *must* do some thinking. See it!

FRANK B. WADE

General Chemistry for Colleges, by Herman T. Briscoe, Professor of Chemistry, Indiana University. First Edition. Pp. viii+872. 3.8×16.75 ×24.25 cm. 262 figures. Cloth. 1935. Houghton Mifflin Co.

In this new college text Professor Briscoe has put much of genuine teaching psychology. His first concern is to give the student an opportunity to understand how the science was developed during the 18th and 19th centuries, what sort of facts were collected and how they were interpreted by the theories that were advanced for that purpose. In thus thinking over after them the great thoughts of the early leaders the student is being educated to *think chemically*. This should be a major end for all teachers of chemistry. The next concern of the text is to give to the student as soon as possible an adequate stock of knowledge of the newer facts and theories and great principles and to lead him to apply the principles and theories to an interpretation of the major types of chemical reaction, and to think and reason intelligently about such chemical problems as come up in his daily life and such as are constantly being heard of or read about in the industrial world.

The order of presentation of subject matter alternates descriptive chemistry with the more theoretical matter so as to use the latter in connection with the former. An open minded attitude toward subject matter which discusses disputed topics is always in evidence. The facts are presented and the several viewpoints briefly given. The student is thus led to see that chemistry is still growing and that it may have "growing pains."

A careful attempt to give the student sufficient reasons for accepting the various principles and theories is always made and he is never made to swallow the material "hook, line and sinker" without any reason being alleged.

A much larger amount of subject matter than can be assimilated by any one class in any one year is given so that the teacher may pick and choose what he will use. This also gives the more ambitious student a chance to

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The Fundamentals of General Chemistry, by Perry A. Bond, Associate Professor of Chemistry, State University of Iowa. First Edition. Pages x+411. 2.75×14.25×21.25 cm. Frontispiece and 68 figures. Cloth. 1935. Farrar & Rinehart, Publishers. Price $3.00.

This new text has the unusual merit of brevity. The author has brought himself to leave out a large number of interesting things, which may lead to the hope that the students who use the text will at least have an opportunity to really take hold upon much of the subject matter and many of the principles and laws to which they will be exposed.

The book drives fast through the preliminary chapters in which, after a brief picture of the weight laws regarding chemical reactions and the classic atomic theory there is presented at once the modern view of the composition of matter with the Laue, Bragg, Debye-Scherrer X-ray background.

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A brief consideration of several parts of the book shows that the treatment of such units as the theory of solutions is conservatively modern. Controversial topics are avoided. The Bronsted nomenclature for acids and bases is frankly given without apology and the Debye-Huckel theory of complete dissociation in moderately concentrated solutions of strong electrolytes is used with discretion. College teachers (and high school teachers too) will do well to take a look at this excellent little text.

FRANK B. WADE

A Combined Laboratory Manual and Work Book in Chemistry, by Kenneth E. Conn, Head of Chemistry Department, Bloomington, Indiana, and Herman T. Briscoe, Professor of Chemistry, Indiana University, Bloomington, Indiana. First Edition. Pages xvi+429. Figures 53. Paper Covers. 1935. Mentzer, Bush & Co.

Although this manual seems to have many pages there are but 73 experiments given in it. Much of the space is taken by instructional material and by new type tests for self administration by the pupil. There are also many problems and questions with space for answers. The work is well related to the textbook material (references are given to seven well known textbooks). Every now and then there is a touch of real human treatment to take off the dullness, for example, when treating covalence the sharing of electrons is likened to a "dutch treat." As may be gathered from the reference to covalence, the book is thoroughly modern. A brief study of the directions for performing the experiments shows them to be clear and

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FRANK B. WADE

Inorganic Preparations, by William Edwards Henderson, Professor of Inorganic Chemistry, The Ohio State University and W. Conard Fernelius, Assistant Professor of Inorganic Chemistry, The Ohio State University. First Edition. Cloth. 1935. Pages xviii+188. 14.5×21 cm. McGraw-Hill Book Company, Inc., New York. Price $2.50.

This book is designed to constitute a part of the advanced work of the college course or may be taken upon entrance to graduate work.

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DRULEY PARKER

Popoff's Quantitative Analysis, revised by Murray J. Rice, Professor of Chemistry, New York State College of Ceramics at Alfred University and Warren P. Cortelyou, Assistant Professor of Chemistry, New York State College of Ceramics at Alfred University. Third Edition. Water proof Cloth. 1935. Pages xxii+555. 19×25 cm. P. Blakiston's Son & Co., 1012 Walnut Street, Philadelphia, Pa.

This book at once commands respect. All of the excellent features of former editions by this masterful teacher are retained but rearranged and in addition much new material has been added. "The new arrangement consists of Book I and Book II. It is intended that Book I will supply the material for an elementary course and Book II the material for an advanced course." The order of presentation is theory, calculations, laboratory. It is believed that the new arrangement will simplify the work of the student and teacher.

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The Calculus, by Hans Dalaker, Professor of Mathematics, University of Minnesota, and Henry E. Hartig, Associate Professor of Electrical Engineering, University of Minnesota. Third Edition. Cloth. Pages vii+276. 14.5×23 cm. 1935. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.25.

This third edition, like the preceding editions, is a well written calculus having abundant material for drill together with numerous interesting applications.

We find no radical departure from the preceding editions. The authors call attention to the following changes.

1. Replacement of some of the exercises with new ones for the purpose of better grading.
2. Addition of more than 200 exercises without answers.
3. Rewording of some statements for the sake of clearness.
4. Replacement of several figures by new ones.
5. Improvements in the chapter on formulas and curves for reference.

J. M. KINNEY

The National Council of Teachers of Mathematics. Tenth Yearbook. The Teaching of Arithmetic. Cloth. Pages vi+289. 15×23 cm. 1935. Bureau of Publications, Teachers College, Columbia University, New York, N. Y.

The Tenth Yearbook of the National Council of Teachers of Mathematics is devoted to the teaching of arithmetic. We find thirteen chapters. Each chapter is written by one or more authors. Each author is well qualified to discuss the particular assigned him. The following topics and the authors are listed in the order found in the book.

I. Psychological Considerations in the Learning and Teaching of Arithmetic. William A. Brownell, Duke University.

II. An Analysis of Instructional Practices in Typical Classes in Schools of the United States. Leo J. Brueckner, University of Minnesota.

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XI. The Mathematical Viewpoint Applied to the Teaching of Elementary School Arithmetic. C. L. Thiele, Detroit Public Schools.

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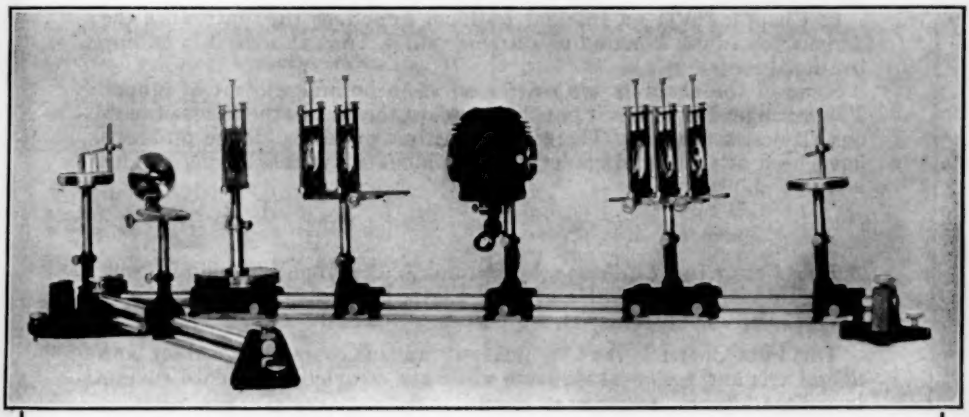

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Teachers of mathematics in the elementary schools, high schools, and colleges should not only read this book, but should see to it that administrators responsible for the supervision of the teaching of arithmetic have an opportunity to read it.

J. M. KINNEY

Elementary College Algebra, by Harry Waldo Kuhn, Professor of Mathematics, and James Henry Weaver, Professor of Mathematics, both of Ohio State University. Cloth. Pages xvii+359. 14×20.5 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.00.

This text belongs to the conventional type of college algebras. There are twenty-two chapters which include the topics usually found in the standard courses. Twelve of these chapters include material given in the standard second course in high school algebra. The earlier chapters have been prepared to give the student an opportunity to review his high school algebra. The authors state that they have included new material in these chapters and cite Chapter V on Functions and Graphs as an example. They claim that in this chapter of nine pages they have presented a fuller discussion of functions and graphs than any found in a high school text. Of course they would not make this claim after having examined some of the modern elementary and high school algebras.

In Chapter XVII on Integral Rational Functions they introduce the derivative and use it in finding extreme values. They also use it in finding irrational roots.

Some of the chapters are written so as to be independent of others. This arrangement makes it possible to adapt the text to the needs of various classes of students. There are numerous problems. These problems have been selected and graded to accommodate students having various levels of ability.

J. M. KINNEY

A First Course in the Calculus, by Hermon L. Slobin and Marvin R. Solt, the University of New Hampshire. Cloth. Pages xi+426. 14.5×21 cm. 1935. Farrar and Rinehart, New York. Price $3.00.

This First Course in the Calculus is a standard course designed for both liberal arts and technical students who have completed standard courses in college algebra, trigonometry, and analytic geometry. The following features deserve mention.

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Sahara, The Great Desert, by E. F. Gautier, Professor in the University of Algiers, Authorized Translation by Dorothy Ford Mayhew, Librarian, Institute of Geographical Exploration, Harvard University. Cloth. Pages xvii+264. 15.5×23.5 cm. 1935. Columbia University Press, 2960 Broadway, New York, N. Y. Price $3.75.

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